

## **TOPICAL REPORT No. 2**

### **CO<sub>2</sub> HUFF-n-PUFF PROCESS IN A LIGHT OIL SHALLOW SHELF CARBONATE RESERVOIR**

(No. DE-FC22-94BC14986--22)

Texaco Exploration & Production Inc.  
Midland, TX

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## General Information

**Field Name:** Slaughter  
**Reservoir Name:** San Andres  
**State:** Texas  
**County:** Hockely  
**Formation(s):** San Andres Fm.  
**RRC District (If Texas):** 8  
**Field discovery date:** April, 1937  
**Current Operator:** Texaco Exploration and Production Inc.  
**Current working interest ownership (names & percentages for all those > 10%):**

Texaco	97.622 %
Mobil	<u>2.378 %</u>
	100.0 %

### **Project description (approximately 500 - 1000 words from public abstract):**

The principal objective of the Sundown Slaughter Unit (SSU) CO<sub>2</sub> Huff-n-Puff (H-n-P) project is to determine the feasibility and practicality of the technology in a waterflooded shallow shelf carbonate environment. Sundown Slaughter Unit is the second demonstration site associated with this project, following the unsuccessful test at Central Vacuum Unit. The ultimate goal will be to develop guidelines based on commonly available data that other operators in the industry can use to investigate the applicability of the process within other fields. The technology transfer objective of the project is to disseminate the knowledge gained through an innovative plan in support of the Department of Energy's (DOE) objective of increasing domestic oil production and deferring the abandonment of shallow shelf carbonate (SSC) reservoirs. Tasks associated with this objective are carried out in what is a timely effort for near-term goals.

### **PURPOSE:**

The goal of this Sundown Slaughter Unit Project is to demonstrate the CO<sub>2</sub> Huff-n-Puff process in a waterflooded, light oil, shallow shelf carbonate reservoir within the Permian Basin. The CO<sub>2</sub> Huff-n-Puff process is a proven enhanced oil recovery technology for Louisiana-Texas gulf coast sandstone reservoirs. The reader is referred to three Society of Petroleum Engineer (SPE) papers, No. 15502, No. 16720 & No. 20208 for a review of the theory, mechanics of the process, and several case histories. The process has even been shown to be moderately effective in conjunction with steam on heavy California crude oils. Although the technology is proven in gulf coast sandstones, it continues to be a very underutilized enhanced recovery option for carbonates.

### **BENEFITS**

The application of CO<sub>2</sub> technologies in Permian Basin carbonates could do for the decade of the 1990's and beyond, what waterflooding did for this region beginning in the 1950's. With an infrastructure for CO<sub>2</sub> deliveries already in place, a successful demonstration of the CO<sub>2</sub> Huff-n-Puff process will have wide application. Profitability of marginal properties will be maintained until such time as pricing justifies a full-

scale CO<sub>2</sub> miscible project. It could maximize recoveries from smaller isolated leases that could never economically support a miscible CO<sub>2</sub> project. The process, when applied during the installation of a full-scale CO<sub>2</sub> miscible project could mitigate up-front negative cash-flows, possibly to the point of allowing a project to be self-funding and increase horizontal sweep efficiency at the same time. Since most full-scale CO<sub>2</sub> miscible projects are focused on the "sweet spots" of a property, the CO<sub>2</sub> Huff-n-Puff process could concurrently maximize recoveries from non-targeted acreage. An added incentive for the early application of the CO<sub>2</sub> Huff-n-Puff process is that it could provide an early measure of CO<sub>2</sub> injectivity of future full-scale CO<sub>2</sub> miscible projects and improve real-time recovery estimates--reducing economic risk. The CO<sub>2</sub> Huff-n-Puff process could bridge the near-term needs of maintaining this large domestic resource base until the mid-term economic conditions support the implementation of the more efficient full-scale miscible CO<sub>2</sub> projects.

#### GENERAL APPROACH & TECHNOLOGY TO BE USED:

The goal of this technology demonstration is to gain an overall understanding of the reservoir qualities that influence CO<sub>2</sub> Huff-n-Puff production responses within a heterogeneous reservoir such as the shallow shelf carbonate environment of the Sundown Slaughter Unit. A generalized reservoir model was developed and used to determine the importance of various geological and operational influences upon the CO<sub>2</sub> Huff-n-Puff process at CVU. The findings at CVU would be applied to the demonstration site at SSU without further simulation studies being conducted at SSU.

It was originally planned to test eight producing wells at CVU with varying reservoir parameters for the field demonstration project. One of those locations was selected for detailed reservoir characterization. This detailed geologic model was used for numerical compositional simulation to finalize the specific design parameters of the field demonstrations, and continued history matching and refinements to the project.

The reservoir characterization and numerical simulation defines the specific volumes of CO<sub>2</sub> required and expected oil recoveries for each of the demonstration sites. The typical process cycle involves the injection of an estimated 1400 tons CO<sub>2</sub> in each producing well. The CO<sub>2</sub> is injected in a miscible condition (at SSU), displacing the majority of the water within the wellbore vicinity, while bypassing the oil-in-place. The CO<sub>2</sub> would be absorbed into both the oil and remaining water. The water would absorb CO<sub>2</sub> quickly, but only a relatively limited quantity. Conversely, the oil can absorb a significant volume of CO<sub>2</sub>, although it is a much slower process. For this reason the producing well is to be shut-in for what is termed a soak period. This soak period normally lasts 1-4 weeks depending upon fluid and reservoir properties. During this soak period the oil experiences significant swelling; viscosity and interfacial tensions will be reduced, and the relative mobility of the oil increases. The no-flow pressure boundary of the waterflood pattern serves to confine the CO<sub>2</sub>, reducing leak-off concerns. When the well is returned to production the mobilized oil is swept to the wellbore by the waterflood. Incremental production is expected to return to its base level within 6-7 months. As shown in SPE papers No. 15497 & No. 20268 with actual field data, and based on parametric simulation findings at CVU, diminishing returns are expected with each successive cycle, thus this proposal is to expose each of the producers to no more than one cycle of the CO<sub>2</sub> Huff-n-Puff process.

#### RESULTS:

Detailed reservoir characterization and simulations were not performed at SSU as they were at CVU. Instead, lessons learned at CVU were applied to the second demonstration site at SSU. Miscible injection operations in this field have verified the reduced injectivity with CO<sub>2</sub> WAG operations--suggesting an ability for gas trapping.. SSU has experienced very pronounced injection hysteresis effects, suggesting the ability for CO<sub>2</sub> to form a near-wellbore gas saturation. Gas trapping was experienced in the test at SSU well number 1341 and some incremental oil was produced.

CO<sub>2</sub> injection commenced on June 16, 1997 and was completed on August 6, 1997. Originally it was planned to inject a total volume of 50 MMcf of CO<sub>2</sub> which would have affected approximately a 100 foot radius from the wellbore. Injectivity was expected to be about 1.0 MMcfD based on other wells in SSU that were on permanent miscible CO<sub>2</sub> injection. Actual injectivity was around 600 McfD. CO<sub>2</sub> injection continued through August 6, 1997 with a total of 34 MMcf being injected into the test well. Injection was

discontinued before the initial target of 50 MMcf was reached because of the lower than expected injection rates encountered. Texaco wanted to get the test completed in a timely manner while still getting a valid test of the Huff-n-Puff process. The radius of CO<sub>2</sub> penetration was calculated to be about 80 feet with 34 MMcf injected which is more than adequate to get a good test. On July 10 an injection profile was run to determine which zones were taking CO<sub>2</sub>. Well 1341 was perforated with 2 jet shots each at 4950, 4954, 4966, 4974, 4981, 4987, 4990, 4996, 5000, 5003, 5008, 5012, and 5016. The perforations at 4950 and 4966 apparently did not take any fluid. Twenty-five percent of the injected fluid went into the perforations at 4996, 5000, and 5003. Notably, 27% of the fluid apparently exited the casing below all of the perforations, i.e. through the casing shoe. The rest of the injection was distributed amongst the remaining perforations. Texaco briefly considered performing a workover to eliminate the injection of CO<sub>2</sub> through the casing shoe but that would have been too costly, time consuming, risky, and of questionable benefit so injection continued until August 6, 1997.

The well was then shut-in for a three-week soak period. The well was placed on production on August 26, 1997 but froze up at the choke due to the pressure drop. Initial production was 100 % CO<sub>2</sub>. A line heater was installed and the well was returned to production on August 29, still making 100% gas (97% CO<sub>2</sub>). The first oil appeared on September 4, 1997 when the well flowed 5 bopd and 16 bwpd. Pressure upstream of the choke had decreased from 1500 psig to 1100 psig during this time while flowing on an 8/64" choke. Oil production fluctuated between 0 bopd and 23 bopd while water production ranged from 0 bwpd to 26 bwpd on 8/64", 9/64", and 10/64" chokes until September 20. On September 21, the choke was opened up to 16/64" with a flowing tubing pressure of 850 psig. Production jumped to 53 bopd and 87 bwpd. The well was choked back the next day to 12/64" due to freezing problems in the choke. On September 26 a production profile log was run to determine which zones were contributing fluid. Consistent with the injection profile the perforations at 4996 and 5000 did not produce any fluid. The perforation at 5016 also did not produce fluid. Forty-two percent of the oil and gas came from the perforation at 4974. The remaining oil and gas was distributed amongst the rest of the perforations below 4974. No oil and gas was produced from below the perforations. Water production was distributed amongst the perforations below 4980. Four percent of the water apparently was produced through the casing shoe. On September 28, the choke was opened up permanently to 45/64" which is wide open, and production for the next three days was 334, 196, and 128 bopd respectively before dropping back to 22 bopd on the fourth day. It should be noted here that the high tests of 334, 196, and 128 are somewhat questionable based on findings later on in the test period and will be discussed in more detail later. Production then fluctuated between 0 bopd and 23 bopd until October 25, when a pumping unit was installed. Flowing tubing pressure had decreased to 50 psig by that time. The first two tests after the pumping unit installation were 90 and 263 bopd respectively. At this time it was discovered that there was a problem with the test facilities. Texaco tested the well through a test separator in the battery; the same test separator that we test all other wells through in that part of the field. Confident was high that accurate tests were being obtained, however it was discovered that the micromotion sensor was interpreting gas laden fluid (oil + water + gas) as a high oil cut fluid, hence the high oil production reported. It is suspected, but not proven, that the same situation may have happened on September 28 when three days of extraordinarily high tests were documented. Unfortunately Texaco can not quantify the degree of error in the tests—if any. Based on simulation results from CVU, increased liquid rates are to be expected when higher gas rates occur so we probably did get some increase in oil and total fluid production. Texaco believes that when the back pressure on the formation was decreased drastically, the well experienced an extraordinary influx of gas which adversely affected the test facilities. On September 28 Texaco opened the choke from 13/64" to 30/64" to 45/64" in a matter of two days. Previous choke size increases were only 1/64 or 2/64". This sudden increase in choke size resulted in a decrease in flowing tubing pressure from 725 psig to 100 psig. Likewise, when Texaco installed the pumping unit, much of the hydrostatic head on the formation was removed, allowing for another influx of gas resulting in another two days of very high tests. By the end of December, production had returned to pre Huff-n-Puff levels of about two BOPD. Cumulative reported production as of December 31, 1997 was 1786 STB of Oil. Even though some of the tests are suspect, for lack of better information, Texaco has assumed the best case scenario for economic purposes. It is obvious that we did get some incremental production from this well. Had the well not been subjected to the Huff-n-Puff technology, production from June 16 through December 31, 1997 (199 days) would have been about 398 STB of oil. It appears that the demonstration recovered about 1388 barrels of incremental oil although that number could be lower.

At this point it appears that the test met with limited success but was an economic failure. Approximately 4300 barrels of incremental oil, i.e. oil over and above what would have been produced under normal operations, would be required to pay out the project. Actual incremental recovery was just 1388 barrels of oil.

**OTHER RELEVANT INFORMATION:**

The San Andres formations produce a 33.0° API oil from an average depth of 5000' within the Sundown Slaughter Unit. The porosity and permeability over the gross pay interval averages 12% and 5.0 md, respectively. Although the residual oil saturation to waterflooding within the near wellbore vicinity has not been determined in detail, carbonate reservoirs typically leave behind a high residual oil saturation in the range of 30-35% in the waterflood swept zones. Oil saturations in other unswept zones, in the heterogeneous reservoir approach initial conditions. This is a significant volume of uncontacted and immobile oil that is the target of this CO<sub>2</sub> Huff-n-Puff technology.

**Project Team Members:**

Those that have contributed during the time period covered in this report...

Scott C. Wehner (Program Manager)  
John Frieditis  
Mark Kovar  
Greg Hinterlong

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**Primary Drive Mechanism:**

Gas Expansion

**Estimated primary recovery factor (%):**

9 % OOIP (assumed equal to 1/4 Ultimate Primary + Secondary since still producing at State allowables upon initiation of waterflood operations. Material balance not performed in this study.

**Estimated incremental Secondary Recovery Factor (%):**

27 % OOIP (see comment above concerning primary recovery efficiency)

**Estimated Total of Primary and Secondary Recovery Factor (%):**

36 % OOIP

**Date of First Production:**

April, 1937 for the field discovery well, J.E.Guerry No. 1.

**Number of Wells drilled in Field (all time):**

Unknown. There are over thirty unitized and non unitized properties in Slaughter Field covering about 125 square miles, thus the difficulty in determining the number of wells. In addition, the total number of wells in the entire Slaughter Field is not relevant to this test although we estimate that there are approximately 3660 producing wells (i.e. not injection wells) in all Fm's/Reservoirs within Slaughter Fd. There are 548 total completions (producing and injection wells) within the SSU unitized formation (San Andres).

**Well Patterns (5-spot, 9-spot, line drive, etc.):**

Sundown Slaughter Unit contains mostly line drive injection patterns.

**Number of Wells penetrating reservoir:**

Unknown. It is estimated that of the approximately 3660 *producing* wellbores existing in the Slaughter field, about 3633 were completed within the subject formations.

**Total completions to date in field:**

Unknown. Estimate approximately 3660 producing well completions in the Slaughter Field.

**Total completions, each reservoir:**

Irrelevant and not readily available to the authors. However, there have been 548 completions within the SSU unitized formation--San Andres.

**Total current producers, each reservoir:**

Unknown (see comment above). However, there are 235 active producers completed within the SSU unitized formation (San Andres).

**Total current injectors, each reservoir:**

Unknown (see comment above). However, there are 285 active injectors completed within the SSU unitized formation (San Andres).

**Number of flowing wells:**

None known. None at Sundown Slaughter Unit.

**Summary field history of SSU (approximately 500 words):**

The Slaughter Field was discovered in 1937 by The Texas Company (Texaco). The field borders the town of Sundown, Texas and is also about 40 miles southwest of Lubbock, Texas. The discovery well was the J.E. Guerry No. 1 located in Tract 83, Block 38 of the Zavala County School Lands in Hockley County, Texas. Upon initial completion the well tested at a rate of 770 bopd with a GOR (Gas Oil Ratio) of 620 standard cubic feet (scf) of gas per barrel of stock tank oil (STB). The well is now referred to as Sundown Slaughter Unit No. 1001. Field development occurred in stages. The first stage of development occurred with drilling in the 1940's and 1950's with the field developed on 35-acre spacing. The wells were produced via solution gas drive. In 1959 waterflooding operations began. In the 1970's additional drilling occurred, reducing the well spacing to 17.7 acres. Additional drilling, particularly horizontal wells, is proceeding to this day. In 1993, nine properties were unitized and in January, 1994, CO<sub>2</sub> flooding operations began in the eastern portion of the field. The CO<sub>2</sub> flood was designed to progress in three phases. Phase one includes 211 wells in the eastern part of the field. Phase two includes 164 wells in the central part of the field and phase three includes 173 wells in the western part of the field. CO<sub>2</sub> flood expansion is currently proceeding into the phase two area.

Primary plus secondary recovery operations produced approximately 36 % of the original oil in place (OOIP = 440 MMSTB). Tertiary operations have contributed an additional 1.3 % OOIP to date. Current field production is about 6000 barrels of oil per day (BOPD), including about 4000 BOPD of incremental tertiary production.

**Project Locations:**

Approximately 40 miles Southwest of Lubbock in Hockley County, Texas



### 3-D Description of Reservoir

#### AERIAL & VERTICAL DESCRIPTION . . .

##### **Aerial Extent:**

Approximately 125 Square miles. About 20 mi. in East - West direction & about 8 mi. in N - S Direction.

##### **Porosity mean, distribution and map:**

The Slaughter Core database was used to analyze porosity relationships. Core data from two wells offsetting the Huff-n-Puff well 1341 are included in digital format (Bernoulli No. 1, CORE & LOGS Subdirectory, Excel format) for review and analysis. Enclosed with this report is also hardcopy output of several porosity/permeability relationships derived from the above database. A map of porosity (PHI) distribution is enclosed in a Appendix to this report.

##### **Original saturation mean, distribution and map:**

*Oil:*  $1 - S_{wi}$

*Water:*  $S_w$ , the average water saturation at discovery for the gross pay column, above -1510 ft (subsea) has been estimated to be 23 %. By electric log analysis and capillary pressure observations, the net pay zones typically averaged 15-18 % over the same gross intervals.

*Gas:* No gas cap was present at discovery.

##### **Saturation distribution map at the inception of cost-share project:**

Not available.

##### **Permeability mean, distribution and map:**

The Slaughter Core database was used to analyze permeability relationships. Core data from two wells offsetting the Huff-n-Puff well 1341 are included in digital format for review and analysis (Bernoulli No. 1, CORE & LOGS Subdirectory, Excel format). A map of permeability-feet (kh) distribution is enclosed in a Appendix to this report.

##### **Directional permeability ( $k_y/k_x$ ):**

Minimal or none. Any preferential flow is thought to occur because of induced fractures.

##### **Pay continuity as a function of well spacing:**

In general, zone continuity is excellent, with the producing zones being correlatable across several well locations.

##### **Reservoir dip (angle and direction):**

In general, the structure is dipping to the South at 20-40' per mile.

##### **Location and extent of faults or other flow barriers (if applicable):**

None known.

**Location and extent of salt domes (if applicable):**

Not applicable.

**Measure of cross flow among reservoir layers:**

None known.

**Average net pay thickness, distribution and map:**

The average net pay thickness within the SSU study area is 87 ft. A map of the S2 net pay (Net Pay Isopach) is included in the Appendix to this report.

**Average gross pay thickness, distribution and map:**

The average gross pay thickness within the SSU study area is 100 ft.

**Number of reservoir layers:**

Macro zonation within the study area identifies the following layering

Upper San Andres (non-productive)  
Lower San Andres:  
    Mallet Pay (M1, M2, M3, & M4 zones)  
    Slaughter Pay (S1, S2, S3, S4 zones)  
    Transition Zone

**Vertical permeability profile(s):**

Vertical permeability averages about 1 md, compared to an average horizontal permeability of 5 md, resulting in an overall 0.20 to one ratio of vertical to horizontal permeability. The effective vertical permeability over any appreciable distance is considered to be negligible due to the many zonations within the subject carbonate formation.

**Vertical porosity profile(s):**

All available porosity logs from the study area have been included in digital format (Bernoulli No. 1, Cores & Logs subdirectory, excel format).

**If gas cap is present . . .**

Gas/Oil contact: No gas cap was present at discovery. No free gas exists currently.

Gas cap bulk volume: No gas cap was present at discovery. No free gas exists currently.

Gas-in-place: No gas cap was present at discovery. No free gas exists currently.

**If aquifer is present . . .**

*Initial oil-water contact:* A study of electrical wireline data suggests that the zero capillary pressure point (100% H<sub>2</sub>O) is in the vicinity of -1510 ft (subsea). A transition zone exists.

*Current oil-water contact:* Varies throughout the field. The Eastern portion of the field is under miscible CO<sub>2</sub> flood and the Western part of the field is under waterflood.

*Aquifer size:* The pay zones within the study area, and the Slaughter field in general are not in communication with the aquifer. Water production was very limited prior to initiating waterflooding operations within the field. With few exceptions, the only water production of any measure was around the periphery of the field--and this volume was limited.

*Water influx rate:* No vertical influence is noted, or expected given the limited vertical permeability. Any water must encroach up from the off-structure locations around the periphery. Higher permeability strata which dips below the pseudo-OWC (discussed previously) probably could expect to see water produced. Again, water production prior to waterflood operations was negligible.

## **GEOLOGIC CHARACTERISTICS**

**Lithology:** The Guadalupian San Andres reservoir zone consists primarily of dolomite with varying percentages of anhydrite. Reservoir complexity stems from the arrangement of the individual crystals and grains. Identification of mineral constituents was obtained from megascopic and microscopic examination of samples from cores taken within and around the Sundown Slaughter Unit (SSU).

**Anhydrite:** This lithology occurs typically in the supratidal facies. The appearance of the lithology is the form characteristic to sabkha environments, the chicken-wire pattern of coalesced nodules. The pattern is formed by the rapid growth of calcium sulfate in the shallow subsurface. The nodule growth displaces the existing bedding and sediments. The lithology may also appear as felted laths in a fine-grained dolomite matrix. In this form the original bedding is not as heavily deformed.

**Mudstones:** The original texture of the sediment that formed this lithology was a carbonate mud. These sediments typically form in very low energy environments or where the fine-grained particles can be stabilized such as by algae. The algal-laminated lithology of the intertidal facies is a common occurrence of these mudstones.

**Wackestones:** This lithology was found primarily in the supratidal and intertidal facies. The original fabric of scattered grains in a lime mud matrix. The grains consisted of pellets and bioclastic debris, mostly bivalves and gastropods.

**Packstones:** This lithology represents deposition in a moderate energy environment. The original fabric is grain supported with carbonate mud filling the interparticle areas. These sediments are produced by wave action keeping most of the carbonate mud in suspension. Although this lithology is most common in the subtidal environment, sudden loss of depositional energy such as storm wash-overs can produce packstones in the supratidal environment.

**Grainstones:** This lithology is produced from sediments without carbonate mud. These sediments require sufficient depositional energy to keep all of the carbonate mud in suspension. These are commonly produced above the wave base in the subtidal environment. Localized sub environments such as tidal channels may produce these sediments within the supratidal or intertidal facies. At deposition, these sediments have the highest permeability.

**Dolostones:** This lithology is represented by rocks that have been diagenetically altered to the point where the original fabric is obliterated. This lithology has the highest porosity to permeability ratio of any of the lithologies present in the reservoir. This lithology forms as small crystals of dolomite dissolve and recrystallize into larger crystals. The total porosity of the system remains relatively unchanged, but the permeability is greatly enhanced as larger pore throats are created.

### **Geologic Age:**

Permian (Guadalupian).

## **Facies Analysis of each reservoir**

### **Depositional Facies:**

During deposition of the reservoir interval, the peritidal sea shallowed and the shoreline moved to the southwest. This shallowing occurred in cyclic events, allowing the interfingering of the three depositional facies, but generally trending from the subtidal to the supratidal facies. This shallowing upward sequence of deposition is responsible for forming the trap for the Slaughter Field, placing the relatively impermeable supratidal deposits over the porous intertidal and subtidal facies. This stratal architecture is also responsible for much of the diagenesis affecting the reservoir flow characteristics.

**Supratidal Facies:** These rocks were deposited in a sabkha environment above the high tide line. Rock characteristics common to this facies include abundant anhydrite in the form of “chicken-wire” or displaceive nodules, occasionally with intervening dolomudstones and/or dolowackestones. The dolomite varies from agal-laminated to peloidal or bioclastic. Fenestral fabric is common. The probable origin of these more grain rich dolomites is the result of storm wave action driving the coarser sediments landward. This facies exhibits low permeability, although the sparse dolomites may contain some porosity. This facies serves as a top seal, vertical flow barriers within the reservoir, and as the updip lateral seal.

**Intertidal Facies:** This facies is composed of agal-laminated, anhydritic, peloidal, dolomudstones, dolowackestones, and dolopackstones. The agal-laminations contribute to a distinctive log response for this facies. These deposits form in the region between the high tide line and the low tide line (between the supratidal and subtidal zones). The porosity to permeability relationship is similar to that of the subtidal facies; however, the intertidal facies tend to have lower porosity and permeability.

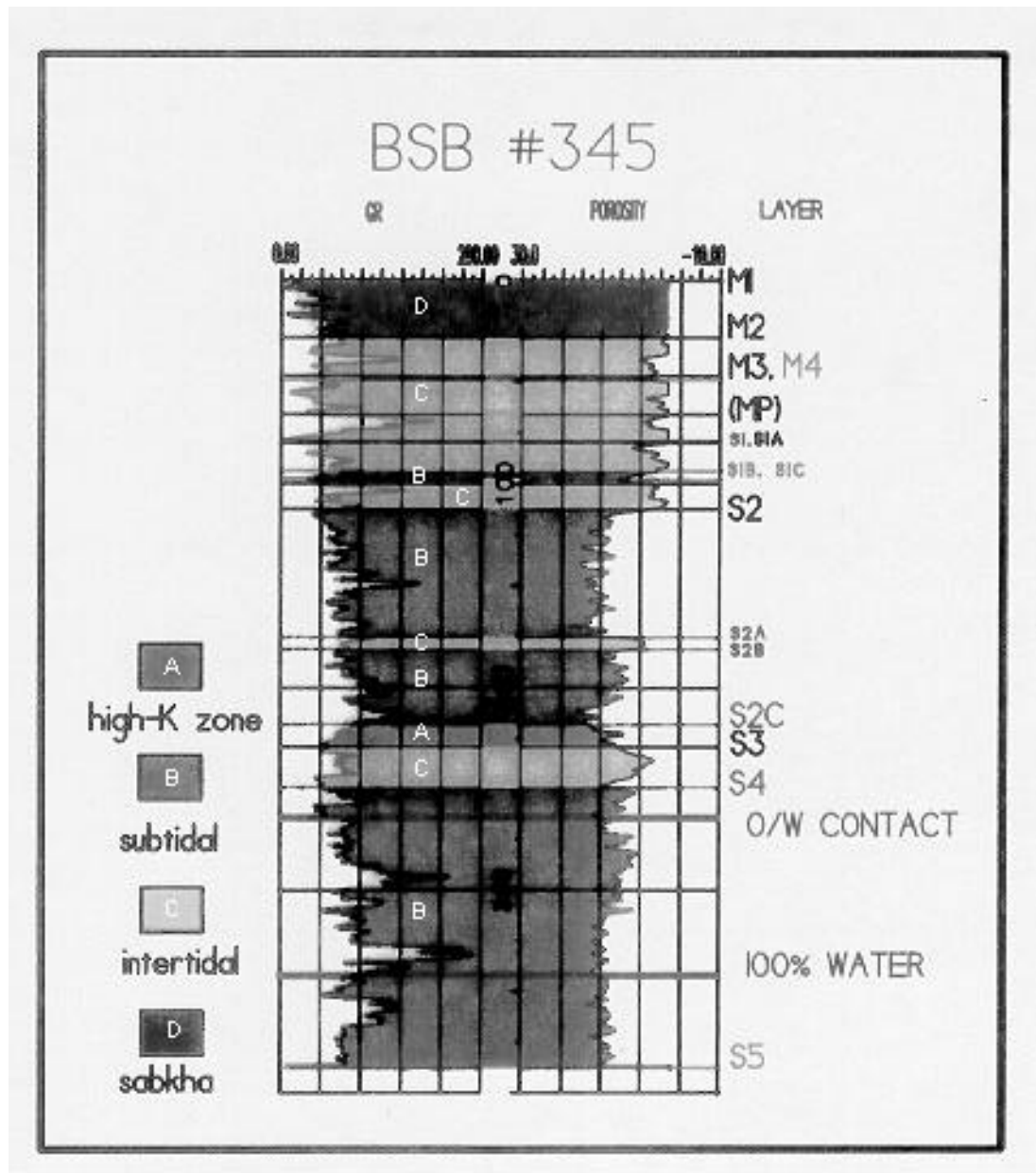
**Subtidal Facies:** The sediments of this facies were deposited below the mean low tide level. Bioclastic and pelletal dolowackestones, dolopackstones, and dolograinstones dominate this facies. As the subtidal environment oscillated between more and less restricted marine, the sediments deposited also varied. These rocks have relatively high porosity and permeability and form the most productive units in the reservoir. Burrows and bioturbation are abundant.

### **Structural style:**

The Levelland/Slaughter fields produce from a broad monoclinal structure on the northern shelf of the Midland Basin. The structure on the top of the producing zone dips to the south at a rate of 20 to 40 feet per mile. The slope during deposition was likely even less than the current 0.5-degree slope. The increase in slope can be attributed to subsidence in the Midland basin to the south. The low depositional slope produced broad facies tracts with relatively uniform thickness. The depositional facies exhibit good lateral continuity. Three distinct depositional facies are observed in cores from the reservoir interval: supratidal, intertidal, and subtidal.

### **Distribution of facies across the project area:**

Two gross intervals comprise the productive interval of the San Andres in SSU, Mallet pay (M1, M2, M3, and M4 zones) and the Slaughter pay (S1, S2, S3, and S4 zones). The subject well (SSU 1341) only penetrated the S2 zone of the Slaughter pay. Recent facies description of the SSU 1330 well core has established further subdivisions of the Slaughter pay based on depositional environment. The facies distribution is shown on the log depicted below from BSB Well No. 345.



M1 zone: This zone is composed entirely of the supratidal facies and acts as the reservoir seal. It is characterized by large volumes of anhydrite mixed with minor amounts of dolomite.

M2 zone: This zone is comprised of intertidal facies in the project area. Although anhydrite is a common constituent, algal-laminated pelletal and bioclastic dolomudstones, dolowackestones, and dolpackstones form the bulk of the zone.

M3 zone: The facies of this zone range from intertidal to subtidal.

M4 zone: The facies of this zone range from intertidal to supratidal.

S1 zone: The facies of this zone range from intertidal to subtidal.

S2 zone: The facies of this zone are dominated by the subtidal environment. Thin intervals of intertidal facies do occur in localized area due to subtle changes in paleotopography.

S3 zone: The zone is composed entirely by intertidal facies.

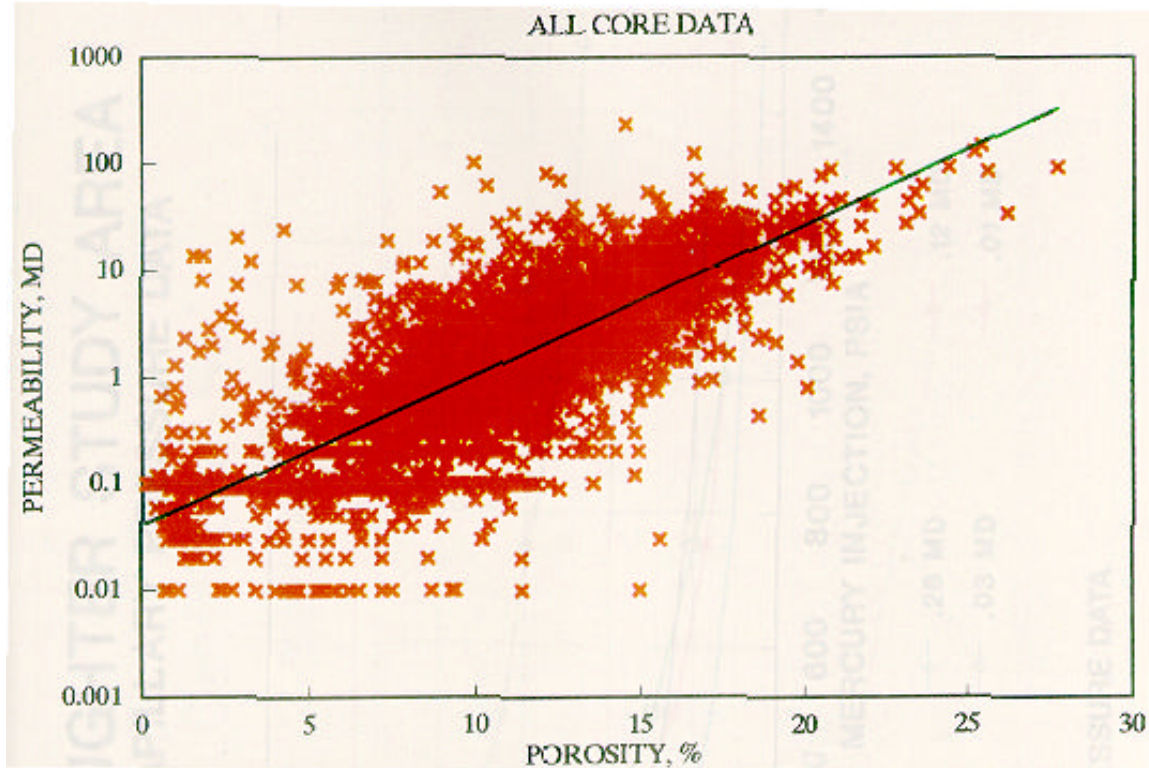
S4 zone: The zone is composed entirely by subtidal facies

**Distribution of porosity, permeability, oil saturation, and net pay by facies:**

Distribution of porosity, permeability (as permeability feet) and net pay are included as maps in the Appendix. The initial oil saturation was assumed to be a constant value of 74% through the pay interval above the transition zone.

**Cross-plot of permeability vs. porosity by facies:**

Data from 46 cores from Texaco operated and offset wells were used in the porosity-permeability cross-plot provided below.



A first order equation best-fit regression line results in a correlation coefficient of 0.61. Historically, this has been considered a good correlation for a San Andres reservoir. Examination of the data cloud indicates that correlation would not be as robust at lower values of permeability. Older vintage cores were analyzed using equipment that was not as accurate as that used on more recent cores. The older analyses reported all reading at or below 0.1 md as 0.1 md. As a result, the value of 0.1 md occurs more often than expected and over a wider range of porosity values.

Various methods to improve the overall correlation were attempted including location and depositional environment. Neither factor contributed significantly to the improvement of the correlation. Core descriptions later detailed the diagenetic overprint altering the depositional pore geometries, blurring the differences between the facies pore geometry.

**Wireline log response to depositional facies:** Log responses were established in the SSU 1330 well for the project area. The most prevalent log type is the gamma ray neutron combination log. Log responses also varied for depositional facies in relation to which pay zone the facies occurred.

Supratidal: The high anhydrite percentage and low porosity dolomite yield very low or negative neutron porosity. Uncompensated neutron logs display high count-rates. The gamma ray response is less distinct but hovers around the

background (“clean line”). Gamma ray “spikes” may occur within the facies due to the thin accumulations of argillaceous or organic material.

**Intertidal:** Neutron porosities are typically less than 10% through the entire section and typically less than 5% within the Mallet pay for this facies. The curve character exhibits a serrate character in response to the agal-laminated dolomites. Porosities are generally low due to the pore filling anhydrite in the Mallet pay. The porosity tends to be higher in the Slaughter pay but significantly less than those of the subtidal facies. There is no distinctive gamma ray response for this facies.

**Subtidal:** This is the high porosity facies comprising most of the Slaughter pay (S1, S2, and S4 zones). The neutron log readings typically exceed 10% and often greater. The gamma ray response is low but slightly above those seen in the supratidal facies. Occasional gamma ray spikes are not uncommon.

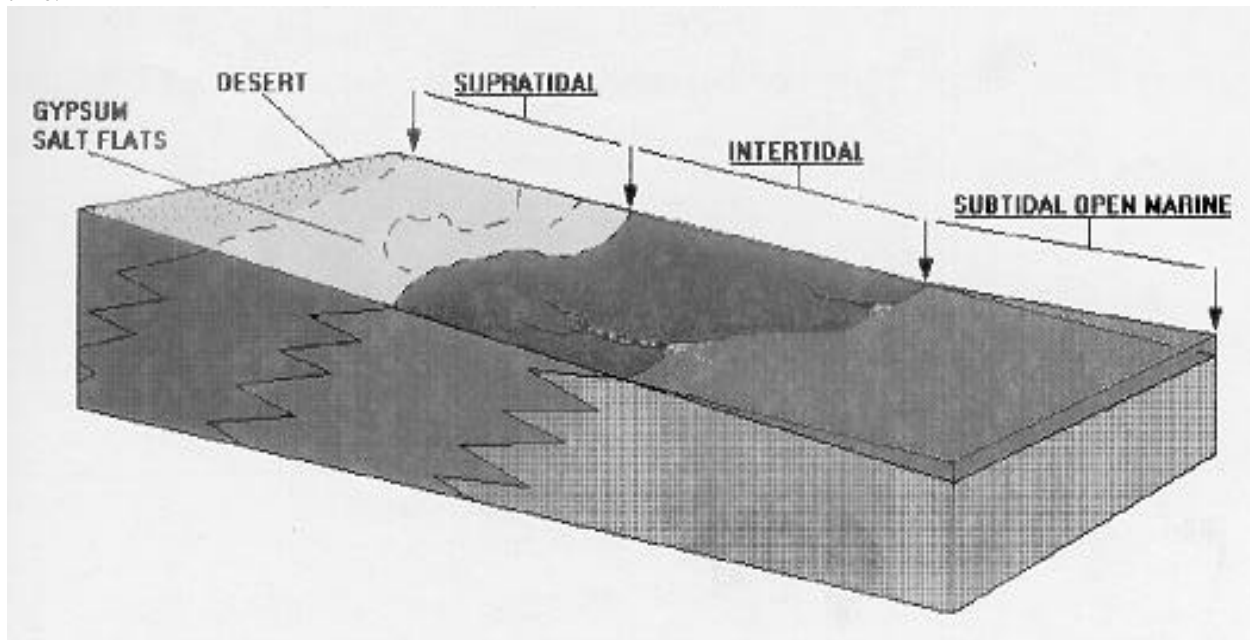
#### **Horizontal continuity and vertical communication of facies:**

To date, the area surrounding the subject well has recovered, on average, 34% of the OOIP. In San Andres reservoirs, recovery factors greater than about 30% indicate reasonable horizontal continuity. No specific tests have been made to analyze the degree of continuity. The diagenetic alteration of the reservoir has increased the vertical communication between facies, particularly the intertidal and subtidal facies. Localized events may produce hindrances to vertical flow within the major units, but not complete barriers.

#### **Description of Geologic Elements:**

##### **Depositional Environments:**

The San Andres carbonates and evaporites penetrated by wells in the Slaughter field are interpreted as deposits of shallow shelf subtidal, intertidal, and tidal flat deposits, and evaporitic sabkha environments. The San Andres section is composed of a series of shallowing upward sequences representing 3<sup>rd</sup> or 4<sup>th</sup> order sea level fluctuations. The block diagram below provides a graphical representation of the relative positions these environments during San Andres time.



#### **Description of depositional facies:**

**Supratidal:** These rocks were deposited in a sabkha environment above the high tide line. Rock characteristics common to this facies include abundant anhydrite in the form of “chicken-wire” or displacive nodules, occasionally with intervening dolomudstones and/or dolowackestones. The dolomite varies from agal-laminated to peloidal or

bioclastic. Fenestral fabric is common. The probable origin of these more grain rich dolomites is the result of storm wave action driving the coarser sediments landward. This facies exhibits low permeability, although the sparse dolomites may contain some porosity. This facies serves as a top seal, vertical flow barriers within the reservoir, and as the updip lateral seal.

**Intertidal:** This facies is composed of agal-laminated, anhydritic, peloidal, dolomudstones, dolowackestones, and dolopackstones. The agal-laminations contribute to a distinctive log response for this facies. These deposits form in the region between the high tide line and the low tide line (between the supratidal and subtidal zones). Sediments in this environment underwent daily exposure with tidal fluctuation. The porosity to permeability relationship is similar to that of the subtidal facies; however, the intertidal facies tend to have lower porosity and permeability.

**Subtidal:** The sediments of this facies were deposited below the mean low tide level. Bioclastic and pelletal dolowackestones, dolopackstones, and dolograinstones dominate this facies. As the subtidal environment oscillated between more and less restricted marine, the sediments deposited also varied. These rocks have relatively high porosity and permeability and form the most productive units in the reservoir. Burrows and bioturbation are abundant.

#### **Reservoir Diagenesis:**

The diagenetic history of the reservoir interval has been interpreted from detailed descriptions of five cores taken in wells surrounding the project area. Ten specific events have occurred in the following order: rim cement; dolomite replacement; compaction; calcite leaching; silica leaching; sulfate filling of moldic pores; sulfate replacement; silica replacement; neomorphism; and dolomite leaching. Although the events progressed in this basic order, there was overlap of the events. Reservoir porosity was enhanced by calcite, silica, and dolomite leaching, while the other events reduced porosity (neomorphism had no net effect on porosity). Increases in permeability resulted primarily from neomorphism and to a lesser extent by dolomite leaching and silica leaching. The other diagenetic events resulted in a decrease in permeability (the calcite leaching had no net effect on permeability).

As can be inferred by the nature of each event, the composition of the original sediment controls to a great extent the magnitude of the effects of specific diagenetic events. For example, sediments without significant volumes of sponge silicious spicules would exhibit little change during silica leaching. The depositional environment controlled the composition (mineralogy) and texture of the original sediments. A significant exception is the neomorphic alteration of crystal size. This process operated independent of the depositional facies.

#### **Evaluation of Reservoir Heterogeneity:**

Numerous studies of the macroscopic and megascopic heterogeneities of the San Andres formation have been published in the geologic and reservoir engineering literature.

Reservoir heterogeneity is best evaluated on the macroscopic level. Evaluation of core samples through laboratory measurements of porosity, permeability, and capillary pressure have been combined with visual descriptions of pore geometry, mineralogy, diagenesis, and fabric. The results of this integration a is working geostatistical model of the of the flow systems in the reservoir.

### **FLUID CHARACTERISTICS**

<b>Initial reservoir pressure:</b>	1750 psia
<b>Log of reservoir pressure vs. production (or time):</b>	Has not been tabulated for the project area.
<b>Reservoir temperature:</b>	Approximately 107° F
<b>Oil Gravity:</b>	33 ° API
<b>Oil viscosity at standard conditions:</b>	4.01 cp (14.7 psia & 107°F)



<b>Oil viscosity at in-situ reservoir conditions:</b>	1.37 cp
<b>Initial Oil Formation Volume Factor (<math>B_{oi}</math>):</b>	1.229
<b>Initial Bubble Point Pressure:</b>	1512 psia at 107°F.
<b>Initial gas in solution (<math>R_s</math>):</b>	460 ft <sup>3</sup> /bbl
<b>Fluid composition test (CO<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>, Hydrocarbons, etc):</b>	Compositional analyses are provided within the various Fluid Analyses provided in a Appendix (Reservoir Fluid Studies Appendix) to this report.
<b>Gas gravity:</b>	0.886 (Air = 1.0; 60°F)
<b>Gas viscosity:</b>	0.0103 cp (14.7 psia & 107°F)
<b>Initial Gas Formation Volume Factor (<math>B_g</math>):</b>	No free gas initially
<b>Log of <math>B_o</math>, <math>R_s</math>, <math>B_g</math> as a function of reservoir pressure:</b>	Not available.
<b>Water density:</b>	Specific Gravity = 0.994
<b>Water viscosity:</b>	0.50 cp @ 107° F
<b>Water Salinity:</b>	Avg. 60,000 ppm

## Field Development History

### RECOVERY TECHNIQUES UTILIZED

#### Primary . . .

*Start date:* Field discovery was 1937, First production from the SSU was April, 1937.

*Project life:* Primary production by gas expansion was utilized in SSU until waterflooding operations were initiated within the SSU in 1959.

*Estimated incremental recovery:* 39.6 MM STB due to primary recovery mechanisms.

*Monthly production by well:* See digital production/injection database included with this report. (Bernoulli No. 1, Production Data subdirectory, excel format)

*Type of injectant:* Primary recovery, by definition does not include any injectant.

*Injection schedule (Bbl/day/well):* See above comment.

*Number and timing of new wells drilled (producer, injection, disposal):* See production database (Bernoulli No. 1, Production Data subdirectory, excel format)

Initial production or injection for a well indicated the month of completion. No disposal wells are utilized. Digital production/injection data is not available prior to 1965. No wells were drilled as part of this DOE contract.

*Number and timing of wells converted (producer, injection or to disposal):* See production database.(Bernoulli No. 1, Production Data subdirectory, excel format). A well with a previous production history which changes to water injection will indicate a conversion. There are no disposal wells in the SSU.

#### Secondary . . .

*Start date:* Most water injection wells within the SSU were drilled/completed during 1959 and 1960.

*Project life:* Secondary operations (waterflooding) have been in progress since 1959.

*Estimated incremental recovery:* Ultimate recovery due to waterflooding is estimated at 118.8 MM STB.

*Monthly production by well:* See production database (Bernoulli No. 1, Production Data subdirectory, excel format)

*Type of injectant:* Water.

*Injection schedule (Bbl/day/well):* See production database (Bernoulli No. 1, Production Data subdirectory, excel format)

*Number and timing of new wells drilled (producer, injection, disposal):* See production database (Bernoulli No. 1, Production Data subdirectory, excel format). Initial production or injection for a well indicated the month of completion. No disposal wells are utilized. No wells were drilled as part of this DOE contract.

*Number and timing of wells converted (producer, injection or to disposal):* See production database (Bernoulli No. 1, Production Data subdirectory, excel format). A well with a previous production history that changes to water injection will indicate a conversion. There are no disposal wells in the SSU.

### **Tertiary . . .**

*Start date:* 1984 (by Amoco in the Slaughter Estate Unit adjacent to SSU); 1994 in SSU.

*Project life:* More than twenty years.

*Estimated incremental recovery:* 14% of OOIP in SSU.

*Monthly production by well:* Production data for wells that are under CO<sub>2</sub> flood are not included as they fall outside of the project area.

*Type of injectant:* CO<sub>2</sub> (Carbon Dioxide)

*Injection schedule (Bbl/day/well):* Injection data for wells that are under CO<sub>2</sub> flood are not included as they fall outside of the project area.

*Number and timing of new wells drilled (producer, injection, disposal):* Data for wells that are under CO<sub>2</sub> flood are not included as they fall outside of the project area.

*Number and timing of wells converted (producer, injection or to disposal):* Data for wells that are under CO<sub>2</sub> flood are not included as they fall outside of the project area.

### **Advanced secondary (including horizontal drilling) . . .**

*Start date:* None within project area.

*Project life:* n/a

*Estimated incremental recovery:* n/a

*Monthly production by well:* n/a

*Type of injectant:* n/a

*Injection schedule (Bbl/day/well):* n/a

*Number and timing of new wells drilled (producer, injection, disposal):* n/a

*Number and timing of wells converted (producer, injection or to disposal):* n/a

### **FOR EACH WELL IN THE PROJECT AREA**

<b>Well Name</b>	SSU 1341
<b>Existing Well or Project Well?</b>	All existing; none drilled for project.
<b>API Reference No.</b>	4221934142

<b>Completion Data</b>	SSU 1341 was drilled in 1994. 8 5/8" surface casing was set at 2242'. 5 1/2" casing was set at 5032' and cemented in place. Well was perforated with 2 jet shots at 4950, 54, 66, 74, 81, 87, 90, 96, 5000, 03, 08, 12 & 16 (total of 26 holes). Well was acidized with 9800 gallons of 20% non-emulsifying HCL and treated with 2 drums of scale inhibitor.
<b>Formation top (MD &amp; TVD)</b>	S2 top at 4949' (4949 TVD)
<b>Formation base (MD &amp; TVD)</b>	The base extends well below current completions and is not recorded.
<b>Total depth (MD &amp; TVD)</b>	5032' and 5032'
<b>Vertical or Horizontal?</b>	Vertical.
<b>Horizontal: radius, lateral, TVD, MD</b>	See above comment.
<b>Status (producing; flowing or artificial lift)</b> <i>Type of artificial lift</i>	Artificial lift Most wells are produced via insert rod (beam) pump. A number of Electrical Submersible Pumps are in operations within the SSU.
<b>Perforated Intervals (MD)</b>	See completion data above
<b>Cored intervals</b>	See digital core database (Bernoulli No. 1, Cores & Logs subdirectory, excel format) and individual description of well 1329.
<b>Completion Type (OH, gravel pack, cased and perforated, etc.)</b>	Cased and perforated (See completion data above.)
<b>Stimulation type (acid, fracture treatment)</b>	See completion data above
<b>Stimulation size</b>	See completion data above
<b>If wells are offshore . . .</b>	
<i>OCS area</i>	n/a
<i>Lease number</i>	n/a
<i>Platform size (well slots)</i>	n/a
<i>Water depth (ft)</i>	n/a

## FIELD PRODUCTION CONSTRAINTS AND DESIGN LOGIC

### Qualitative review of reservoir description and development history:

#### CVU-Demonstration site No. 1 (discussed in Topical Rpt. No. 1):

The reservoir is a carbonate deposited in a shallow shelf environment. Structurally, the CVU is in a very good position within the field. Most of the reservoir has responded in a textbook fashion to waterflooding, except for the far south and northeast regions. The northeast area is simply becoming more mixed with Sabka depositional strata. The south dips sharply at the margin of the Delaware Basin and become much more heterogeneous/discontinuous. There are a few sandstone members, none of which exist over the entire field/study area. The sandstones have considerable carbonate material mixed in and is considered to be non-pay due to its relatively low permeability. The Grayburg dolomite is a minor pay contributor. The major pay is the Upper and Lower San Andres zones. Carbonates above 7.0% porosity contribute to 98.0% of the flow capacity of these zones. As San Andres reservoirs go, the Vacuum field is at the high end of quality. Continuity is fairly good in some locations with the average permeability near 22.0% in the pay zones.

The Vacuum Field was discovered in May, 1929 by the Socony Vacuum Oil Company--now known as Mobil. The discovery well was the New Mexico "Bridges" State Well No. 1 (drilled on the section line of Sec's 13 & 14, T16S R34E). The well was shut-in until 1937 when pipeline facilities became available to the area. Field development began in late 1937 and by 1941, 327 wells had been completed on 40-acre spacings. By year 1947, the field had been extended approximately two miles to the west. Scattered reservoir development continued slowly over the next two decades. There was not much emphasis directed at the Vacuum Field properties since the majority were producing at state "allowable." Because the wells situated most favorably were expected to continue at "allowable" the peripheral properties would become the first targets of attention. The first enhanced recovery attempt in the Vacuum Field was a pilot waterflood by Socony Vacuum (Mobil) which began December 1958. Enhanced recovery on the Texaco leases began with the unitization of the West Vacuum Unit (WVU) with waterflooding beginning in 1966. In 1972-73 a second stage of reservoir development began with the unitization of the Vacuum Grayburg-San Andres Unit (VGSAU) and infill drilling which reduced the well spacing to 20-acre. The VGSAU waterflood was initiated in 1973. ARCO initiated their State Vacuum Unit in 1977. The Central Vacuum Unit (CVU) became official in 1977 with water injection beginning in 1978. The CVU was infill drilled on 20-acre spacings during the period 1978-1982. Phillip's East Vacuum Grayburg-San Andres Unit began in 1978 along with a co-op flood in Section 35. A polymer augmented waterflood was incorporated and completed during the 1980's on both the VGSAU & CVU. Other operators in the Vacuum field also implemented Polymer floods due to incentives available to reduce the Windfall Profits Taxation burdens. Further reservoir development began in 1987 with infill drilling on 10-acre spacings at the CVU. Infill drilling continues sporadically. Enhanced recovery operations by waterflooding are in progress across the entire Vacuum field, and Carbon Dioxide Miscible Flooding (CO<sub>2</sub>) was initiated by Phillips in the southeastern portion of the field in 1985. A Miscible CO<sub>2</sub> flood was also initiated at the State35 Unit (Phillips) and CVU in 1996 and 1997, respectively. In addition to the San Andres/Grayburg producing horizons, there are 12 other formations that are, or have been productive in the Vacuum field. These, mostly deeper horizons were developed predominantly during the 1960's.

#### SSU-Demonstration Site No. 2:

The reservoir at Sundown Slaughter Unit also is a carbonate (dolomite) deposited in a marine shallow shelf environment of very low relief. The project area is located near the southern edge of the Slaughter/Levelland field. Response to secondary recovery methods is quite variable, reflecting the geologic heterogeneity of the formation. Permeability ranges from less than 1 md to over 230 md, with an average of about 5 md. Porosity ranges from 0.1% to 27.7%, with an average of 12 %. Continuity is fairly good through the unit; however, abrupt changes are not uncommon.

The Slaughter Field was discovered in 1937 by The Texas Company (Texaco). The field borders the town of Sundown, Texas and is also about 40 miles southwest of Lubbock, Texas. The discovery well was the J.E. Guerry No. 1 located in Tract 83, Block 38 of the Zavala County School Lands in Hockley County, Texas. Upon initial completion the well tested at a rate of 770 bopd with a GOR (Gas Oil Ratio) of 620 standard cubic feet (scf) of gas per barrel of oil. The well is now referred to as Sundown Slaughter Unit No. 1001.

Texaco's field development occurred in stages. The first stage of development occurred with drilling in the 1940's and 1950's with the field developed on 35 acre spacing. The wells were produced via solution gas drive. In 1959 waterflooding operations began. In the 1970's additional drilling occurred, reducing the well spacing to 17.7 acres. Additional drilling, particularly horizontal wells, is proceeding to this day. In 1993, nine properties were unitized and in January, 1994, CO<sub>2</sub> flooding operations began in the eastern portion of the field. The CO<sub>2</sub> flood was designed to progress in three phases. Phase one includes 211 wells in the eastern part of the field. Phase two includes 164 wells in the central part of the field and phase three includes 173 wells in the western part of the field. CO<sub>2</sub> flood expansion is currently proceeding into the phase two area. Primary plus secondary recovery operations produced approximately 36 % of the original oil in place (440 MM stock tank barrels). Tertiary operations have contributed an additional 1.3 % OOIP to date. Current field production is about 6500 barrels of oil per day (bopd), including about 4000 bopd of incremental tertiary production.

There are currently eight active CO<sub>2</sub> floods in Slaughter Field, including the Sundown Slaughter Unit. Four of these projects are adjacent to SSU. Amoco was the first operator in Slaughter Field to initiate a full scale CO<sub>2</sub> flood. That occurred in 1984 following a successful pilot flood.

#### **Problem statement - constraints on further producibility . . .**

*Technological:* Heterogeneous reservoirs, such as the Shallow Shelf Carbonate depositional environment at Slaughter field leads to poor aerial and vertical sweep efficiencies. Most notably the hydrocarbon saturation remains relatively high in the near wellbore vicinity of producing wells in waterfloods.

*Economical:* Low crude oil prices. No federal energy policy. High overhead distribution from large corporate structures. Unfair taxing procedures on Major Oil Companies. Major's should be looked at as simply a group of subsidiaries below a parent. Each must function as a separate entity, which is some times smaller than larger independents in the same business area. Yet, because they are "integrated" corporations they are disproportionately taxed relative to the other companies. In reality, the integration comes from the downstream operations, which over the last decade have resulted in losses to the bottom line in many cases. Double jeopardy, on top of the corporate overhead distributions.

*Environmental:* Too many costly restrictions resulting in a poor cost/benefit ratio.

*Operational:* Low pressure gathering systems will restrict the ultimate flow back rate of the demonstration well. Ideally, the well would be produced back as quickly as possible but low pressure gathering lines and low pressure test vessels will require back pressure and restricted flow back rates. Must have a disposal option for hydrocarbon laden CO<sub>2</sub> gas stream.

**Method of problem detection:** Material balance and volumetric calculations of reservoir conditions. Wireline log analysis. Infill drilling results. All support a significant hydrocarbon saturation left behind in the field.

*Application of new tools or techniques:*

*Inconsistency between the design and actual performance:* Not applicable. No simulation was performed for the SSU site.

**Proposed solution for reduction of constraints:** Field demonstration of CO<sub>2</sub> Huff-n-Puff process in Budget Period No. 2.

*Development plan for project impact and projected incremental production:* No further development is planned for the SSU site. Incremental production was 1388 barrels of oil which was not enough to pay out project costs.

*Actual implementation of project; noting any departures from plan:* The volume of CO<sub>2</sub> injected was reduced from the planned volume of 50 MMCF to 34 MMCF during the project because of lower than expected injectivity. The change was made so as to complete the project in a timely manner without compromising the integrity of the test.

### **Evaluation . . .**

*Actual impact on the project's reserves and production; interpretation of any differences from projection:*  
No impact on reserves or production.

*Assessment of potential value of the proposed work to fields/reservoirs of similar type:* Although the project at SSU was not economically successful, it did recover some incremental oil, making it somewhat of a technological success, proving that the technique will work in shallow shelf carbonate environments. The reservoir at SSU was amenable to near wellbore gas trapping which appears to be necessary for the recovery of incremental oil. Since the project at CVU did not trap any of the injected CO<sub>2</sub> and also did not recover incremental oil while the SSU project did trap gas and did recover incremental oil, a good first step in identifying future candidates would be to evaluate the reservoirs ability to trap gas. In addition, future projects should attempt to include a method of production such that the flow rate is not restricted, or at least the restriction is minimized so that the well is given an opportunity to flow at maximum rates.

## Evaluation of Cost-Share Project Results

### TYPE OF PROJECT

<b>Secondary:</b>	n/a
<b>Tertiary:</b>	CO <sub>2</sub> Huff-n-Puff demonstration.
<b>Advanced secondary (including horizontal drilling):</b>	n/a

### INJECTION PROGRAM

<b>Type of Injectant:</b>	Carbon Dioxide (CO <sub>2</sub> )
<b>Injection schedule (volume/day/well):</b>	664 MCF per day on average.
<b>Injection pattern (before the inception of cost-shared project and proposal):</b>	17 -Acre Line drive pattern.
<b>Number and schedule of new producers drilled:</b>	None. Use existing wellbores.
<b>Number and schedule of new injectors drilled:</b>	None. Use existing wellbores.
<b>Number and schedule of conversion wells:</b>	None. Producer used temporarily as injector to place CO <sub>2</sub> only, then turned around to produce fluids.

### SIMULATION STUDY

<b>Type of simulator utilized:</b>	No simulation was performed. See Topical Report No. 1 for simulation studies performed for Demonstration Site No. 1 at CVU.
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**Complete set of rock and fluid data used in the simulator:** Not applicable

### PROJECT ECONOMICS

**Incremental non-drilling capital costs (compressors, etc.):** \$ 12,602

**Fixed operating cost (lifting cost, etc.):**

**Process dependent operating costs (\$/well/month):**

1.) *Injectant purchase cost:* \$ 22,981 (Total project cost)

2.) *Injection and recycling cost:* (Total project cost)

Processing cost for recycled CO <sub>2</sub>	\$1,762
Service unit cost -	\$14,788
Labor costs to install flowline -	\$6,212
Inline heater and propane	\$3,547
Trucking	\$8,485
Wireline (injection and production profiles)	\$3,497
<u>Produced gas analysis</u>	<u>\$4,036</u>
Total	\$42,327



3.) *Treatment and disposal costs:* Not applicable

**Drilling and completion costs (\$/well):** No wells drilled as part of this contract/project

**Reservoir description costs . . .**

1.) *Data gathering and processing (logs, cores, seismic):* N/A

2.) *Reservoir simulation study:* N/A

3.) *Other:* N/A

## Supporting Data

**Logs** ( open-hole logs for demonstration well and all direct offset wells.): See digital log database (Bernoulli No. 1; Cores & Logs subdirectory).

**Available maps** (oil Isopach, porosity distribution, structure, OWC, etc.): All maps have been included in the Appendix to this report.

**Cross sections:** Two hardcopy cross sections through the demonstration site are included in the Appendix.

**Seismic sections:** No seismic information was acquired as part of this project.

**3-D seismic interpretations:** None performed as part of this project.

**PVT analysis reports:** Included with Reservoir Fluid Analyses in Appendix to this report.

**Core analysis reports:** See Core Database (Bernoulli No. 1; Cores & Logs).

**Core descriptions and thin sections:** Please see core description of well 1329 included in Appendix.

**Directional surveys:** Not Applicable.

**Well schematics:** See Wellbore Schematic (Bernoulli No. 1, 1341 schematic)

**Injectivity Tests:** None known to exist in demonstration area.

**Well completion reports:** See Texas Railroad Commission form W-2's for demonstration area wells (Appendix "A").

**Well workover histories:** Not applicable

**Simulation output:** None performed as a part of this project.

### Special laboratory studies . . .

*Rock/chemical compatibility tests:* None performed.

*Fracture descriptions:* None known to exist.

*Mechanical preparation:* None.

*Minimum miscibility pressure measurements:* 1512 psia. The MMP studies for Slaughter reservoir fluid are included with reservoir fluid studies in a Appendix to this report (Reservoir Fluid Studies).

*Special Core flood tests:* None performed as a part of this project.

**Results of pilot flood tests:** None conducted.

**DST reports:** None known to exist in the demonstration study area.

**Pressure buildup or drawdown tests:** None conducted as part of this study.

**Tracer studies:** No known chemical tracer studies were, or have been conducted in the SSU.

## **Environmental Information**

**Surface elevation:** 3,570 ft. above sea level.

**Surface conditions (plains, wetlands, etc.):** High desert plains. Flat w/ few features. No/Little sandy soil on exposed caliche.

**Distance from navigable surface water (if < 5 mi.):** More than 5 miles

**Distance from air quality non-attainment area (if < 20 mi.):** Greater than 20 miles.

**Location (depth) of groundwater < 10,000 TDS:** Ogallala Fm. is found as shallow as 80 ft from surface.

**Depth of surface casing:** First Casing string is set at 2242' KB (KB elevation is 3580' above sea level)

**Volume of produced water:** Maximum daily production during test period was 590 bwpd.

**Produced water quality (if state requires tests):** Not required.

**Produced water treatment/disposal methods used:** Produced water is recycled within the existing waterflood. Excess produced water, over and above the capacity of the water injection wells, is sent outside the Unit to be disposed of.

**Volume of drilling wastes from new wells:** None drilled as part of this project.

**Drilling mud content for new wells:** Not applicable to this project, see comment above.

**Drilling mud handling practice (closed system, lined pit, unlined pit):** Not applicable to this project, see comment above.

**Location, size, purpose of any surface impoundments at site:** Not applicable. None at demonstration site.

**Results of recent mechanical integrity tests:** The casing was successfully tested to 500 psig prior to conducting the Huff-n-Puff test

**Results of "Area of Review" studies for injection wells:** Area of Review is performed when permitting new injection wells or a change in mode of operations. The demonstration site is within an area of recent infill drilling. The entire area passed the Area of Review investigation at that time.

## **APPENDIX “A”**

*Maps*

*Cross Sections*

*Reservoir Fluid Analyses  
&  
PVT Data*

*Slaughter Core Database Extract*

*Form W-2: Completion/Stimulation Data  
State of TX Completion Reports*

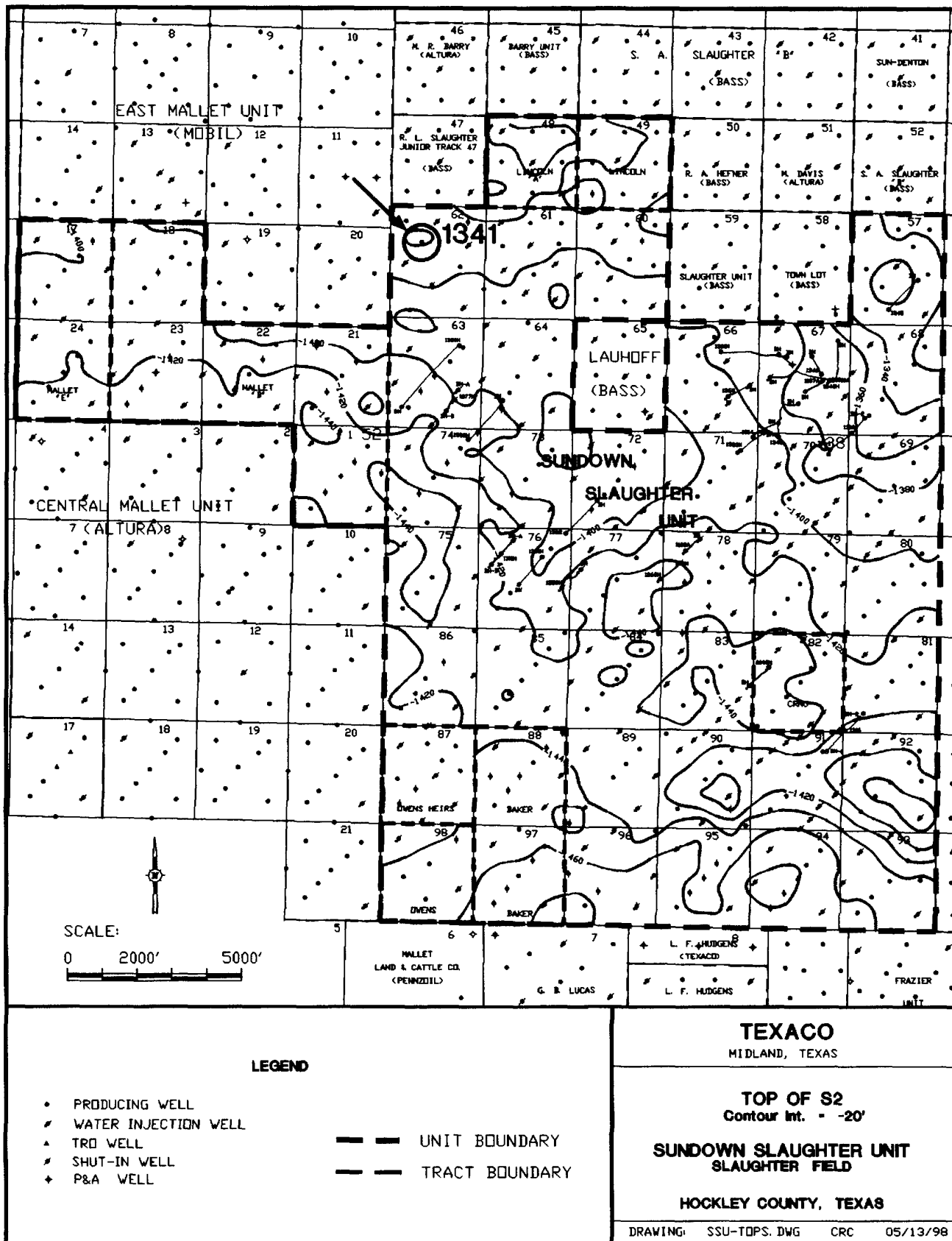
**SUNDOWN SLAUGHTER UNIT**

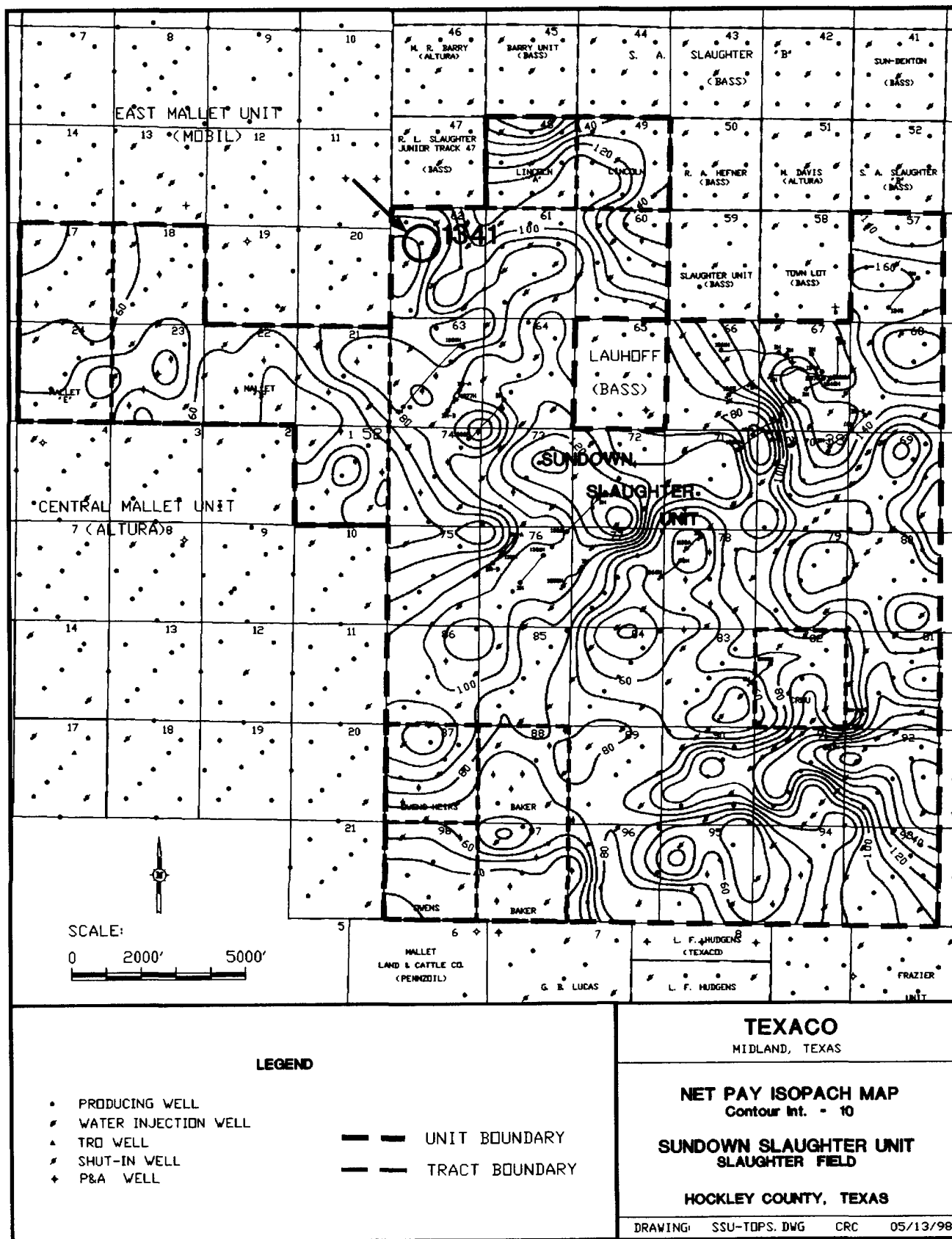
**CO<sub>2</sub> HUFF-n-PUFF**

**DEMONSTRATION AREA**

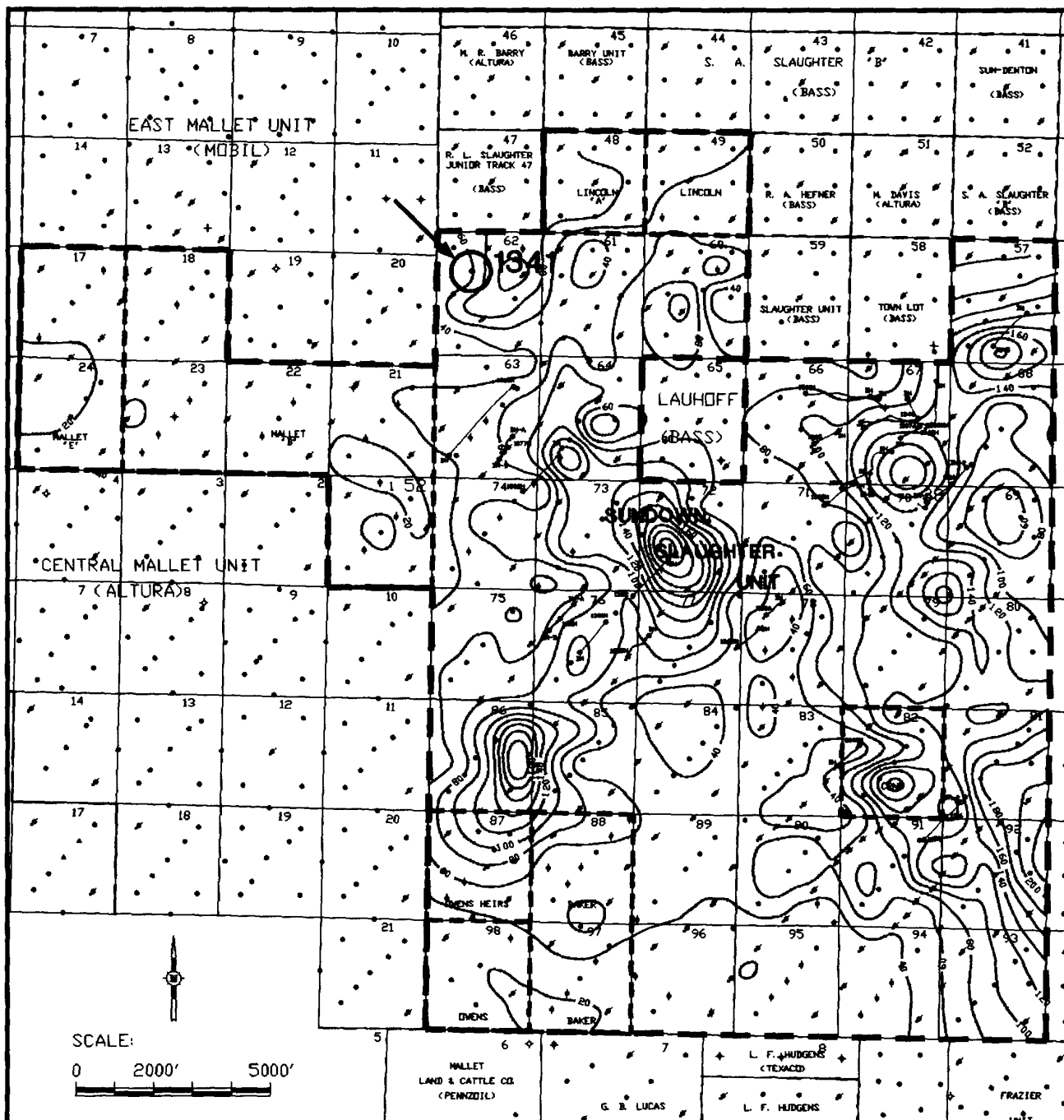
# MAPS











# LEGEND

- PRODUCING WELL
- WATER INJECTION WELL
- ▲ TRO WELL
- SHUT-IN WELL
- P&A WELL

- UNIT BOUNDARY
- TRACT BOUNDARY

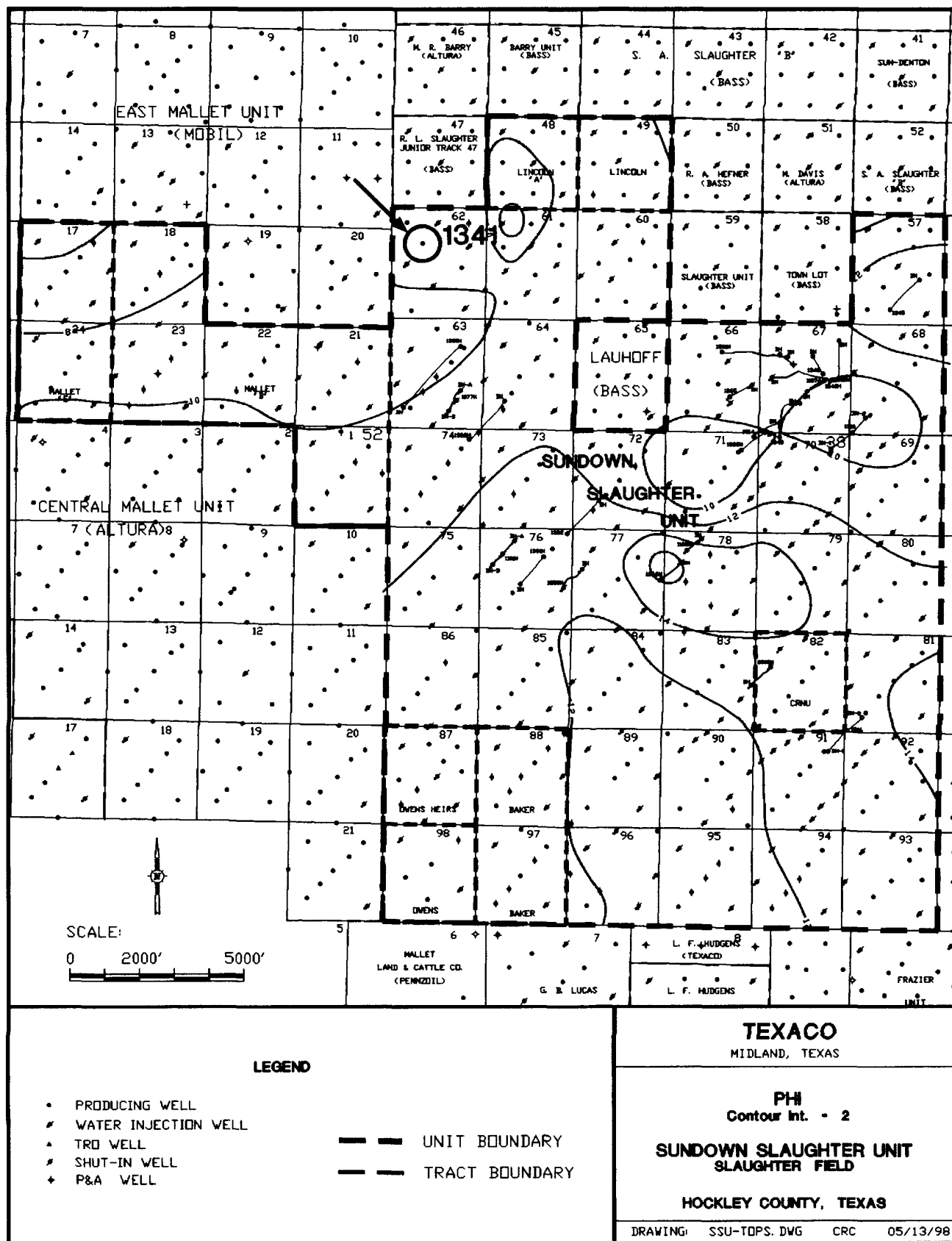
TEXACO  
MIDLAND, TEXAS

KWH  
Contour Int. = 20

SUNDOWN SLAUGHTER UNIT  
SLAUGHTER FIELD

HOCKLEY COUNTY, TEXAS

DRAWING: SSU-TOPS. DWG CRC 05/13/98



# **CROSS SECTIONS**

Sundown Slaughter Unit  
1029A

Sundown Slaughter Unit  
1341

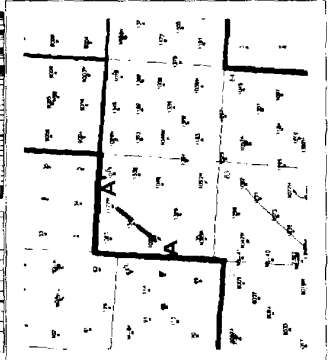
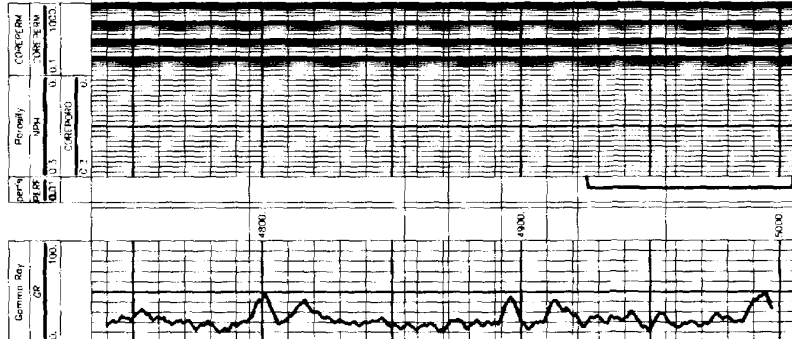
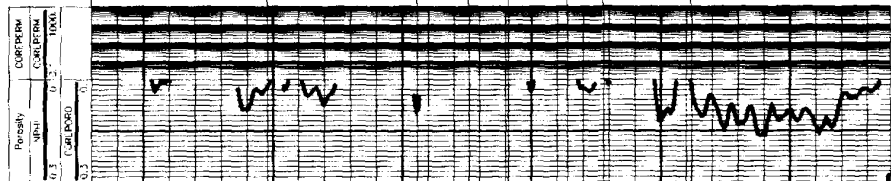
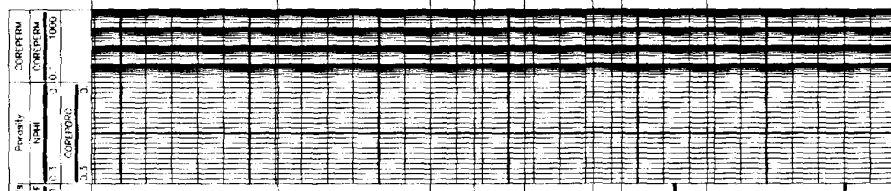
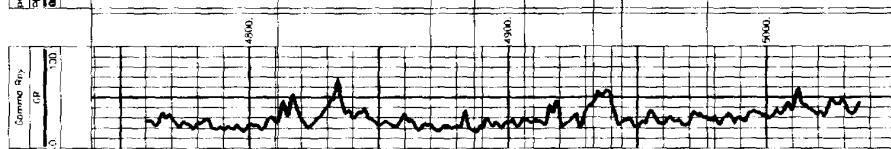
Sundown Slaughter Unit  
1177W

A

Q

Q

A'



SM

M1

M2

M4

MP

S1

S2

-1150.

-1250.

-1350.

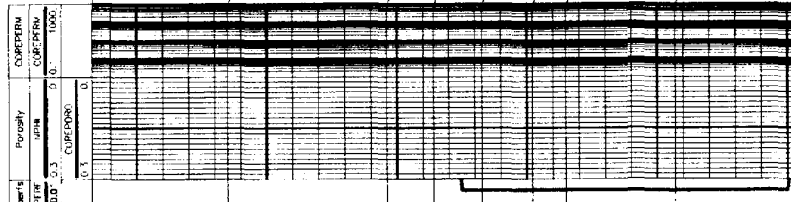
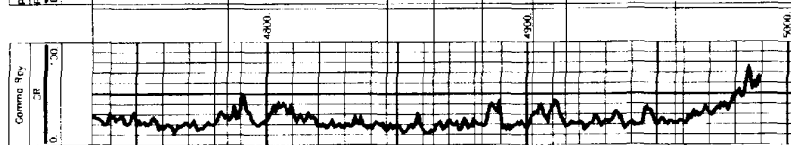
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-1450.

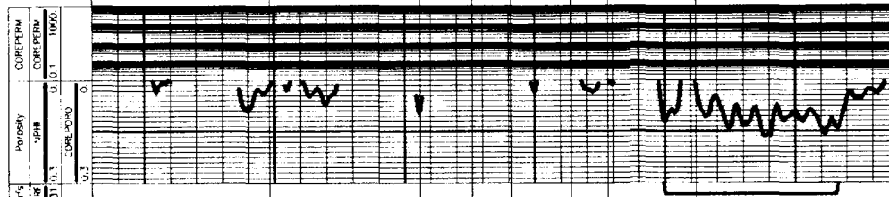
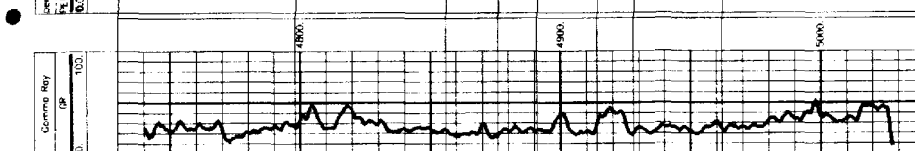
-1450.

Sundown Slaughter Unit  
1023

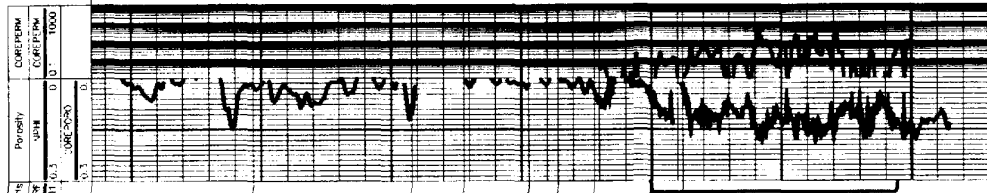
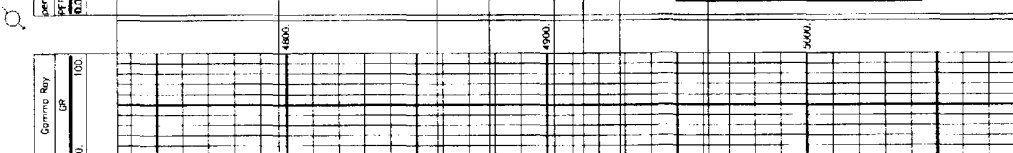
B



Sundown Slaughter Unit  
1341



Sundown Slaughter Unit  
1329



SM

M1

M2

M4

MP

S1

S2



-1150. -1250. -1350. -1450.

**RESERVOIR**

**FLUID**

**ANALYSES**

**&**

**PVT DATA**

---



DATE: April 5, 1993

TO: Ms. Lois Folger  
Midland, TX

FROM: J. F. Stevens  
E & P Technology Department  
Houston, TX

SUBJECT: PRO - FIELDS AND WELLS  
Slaughter Live Oil MMP Results

As requested by telephone conversation on Friday, April 2, 1993, a summary of the MMP results are given below.

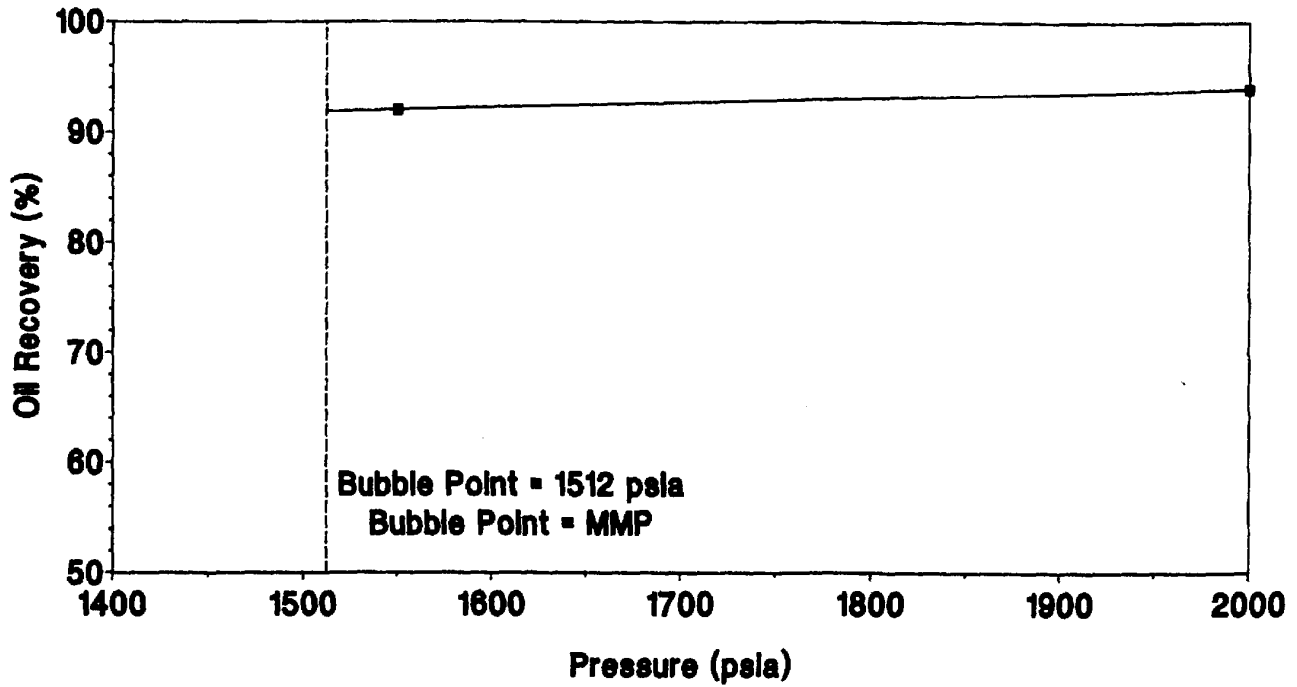
The MMP for Slaughter Live Oil at 107°F using pure carbon dioxide is the bubble point pressure of the oil or 1512 psia as shown in the attached Figure 1. The two data points at 1550 and 2000 psia clearly show that the recoveries are very high, indicating miscibility. This is shown graphically in Figures 1 and 2.

The data is being given to Charlie Cheng for possible simulation work. A report is currently being written and will be sent to you shortly. If you have any questions, please call me at texnet 659-6306 or Jack Benard at 659-6169.

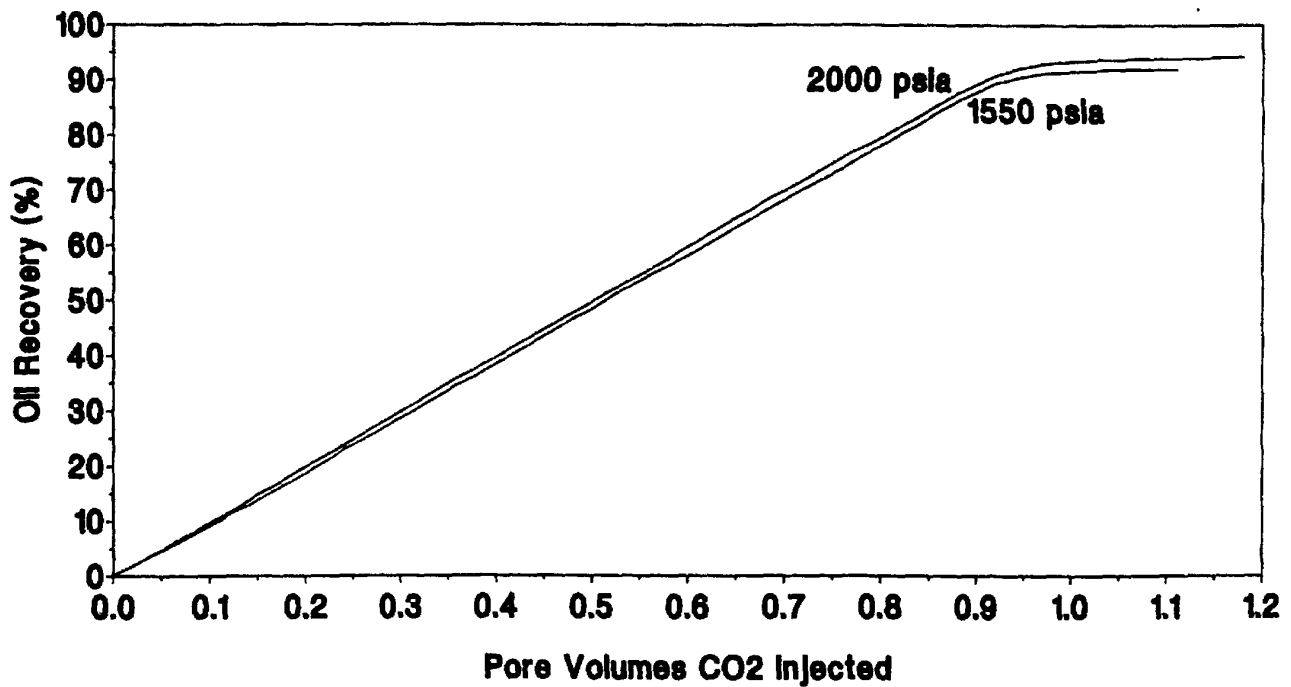
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Attachment

**Figure 1. Slaughter Live Oil MMP**  
**Solvent: Carbon Dioxide 107F**



**Figure 2. Slaughter Live Oil MMP**  
**Solvent: Carbon Dioxide 107F**





**RESERVOIR FLUIDS ANALYSIS**

**FOR**

**TEXACO E & P INC.  
BOB SLAUGHTER BLK. #152 WELL  
SLAUGHTER FIELD  
HOCKLEY COUNTY, TEXAS**

March 11, 1993

Ms. Lois K. Folger  
Texaco Exploration & Production, Inc.  
P. O. Box 3109  
Midland, Texas 79702

Dear Ms. Folger:

Subject: Reservoir Fluid Analysis  
Bob Slaughter Blk. #152 Well  
Slaughter Field  
Hockley County, Texas

Attached are the results of the analyses of the recombined separator oil and gas from the subject well. The separator oil and gas were initial recombined to the average gas oil ratio of 450 standard cubic feet of gas per barrel of stock tank oil. The saturation pressure (1725 psia at 107°F) of this fluid was found to be greater than previous field bubble points (see results of these analyses in Tables 9 thru. 11). AS per your instructions, this reservoir fluid was adjusted to a bubble point pressure of 1515 psia at 107°F. This fluid was then used for the study.

Compositional analyses, pressure-volume relations, differential liberation, viscosity determination, and separator flash liberations were conducted using the recombined reservoir fluid.

A portion of the recombined sample was transferred to our high-pressure cell at 107°F and pressure-volume relations on a constant weight of the reservoir fluid were determined. At this temperature, the bubble point was determined to be 1515 psia. A differential liberation was performed on this portion of the fluid at six pressure decrements. A total of 449 cubic feet of gas at 14.65 psia and 60°F were liberated per barrel of residual oil at 60°F. The associated formation volume factor measured at the saturation pressure during the liberation was determined to be 1.218 barrels of reservoir fluid per barrel of the residual fluid (32.2°API) at 60°F.

Separator flash liberation tests were run at separator pressures of 29 and 0 psig at 72°F. Composition of the sales gas, surface formation volume factor, solution gas-oil ratio and API gravity of the stock tank oil are also presented in this report.

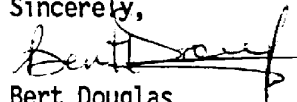
Ms. L. K. Folger  
Page 2.  
March 11, 1993

Viscosity of the reservoir fluid was measured in a rolling ball viscometer at the same temperature and pressures of the differential liberation.

Results of compositional analyses of the separator gas, separator oil, calculated wellstream to heptanes plus fraction and the recombined bubble point fluid composition to undecanes plus fraction are also attached.

We greatly appreciate this opportunity to be of service to you. If you have any questions, please do not hesitate to contact us.

Sincerely,

A handwritten signature in dark ink, appearing to read "Bert Douglas", written over a horizontal line.

Bert Douglas  
Director of Technical Services

Attachments

BD/fp

## SAMPLING INFORMATION

## WELL RECORD

Company	Texaco E & P Inc.
Well	Bob Slaughter Blk. #152
Field	Slaughter
Location	Hockley County, Texas

## FIELD CHARACTERISTICS

Formation Name	San Andres
Sand Name or Designation	--
Date Completed	3-31-1944
Original Reservoir Pressure (psig)	1750

## WELL CHARACTERISTICS

Original Produced Gas-Oil Ratio (scf/bbl)	451
Perforations (ft)	4900 - 5000 (Open Hole)
Elevations (ft)	3525 G.L.
Total Depth (ft)	5000
Last Reservoir Pressure (psig)	1444 (7-25-92)
Reservoir Temperature (°F)	107
Information Provided By	L. K. Folger

## SAMPLING CONDITIONS

Date Sampled	February 17, 1993
Flowing Tubing Pressure (psig)	--
Primary Separator Temperature (°F)	39 (Oil), 24 (Gas)
Primary Separator Pressure (psig)	29
Primary Separator Gas Rate (mscf/day)	7.3 MCFD
Primary Separator Oil Rate (bbl/day)	10 BOPD
Second-Stage Separator Pressure (psig)	--
Second-Stage Separator Temperature (°F)	--
Second-Stage Gas Rate (mscf/day)	--
Second-Stage Oil Rate (bbl/day)	--
Stock Tank Oil Rate (bbl/day)	10 BOPD
Separator Gas-Oil Ratio (scf/bbl)	733
Primary Separator Gas to Stock Tank Oil Ratio (scf/bbl)	--
Time Sample Taken	10:00 am
Sample Taken By	Tefteller

Standard cubic feet at 14.65 psia and 60°F  
 Oil rate for gas-oil ratio measured at First Stage

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 1. EXTENDED ANALYSIS OF RECOMBINED SAMPLE

Component	Mole %	Specific Gravity (60/60°F)	Molecular Weight
Nitrogen	1.57		
Carbon Dioxide	5.68		
Hydrogen Sulfide	1.44		
Methane	21.29		
Ethane	6.26		
Propane	5.40		
i-Butane	1.23		
n-Butane	3.51		
i-Pentane	1.83		
n-Pentane	2.28		
Hexanes	4.84		
Heptanes	8.26	0.7227	101
Octanes	6.93	0.7457	111
Nonanes	6.25	0.7648	124
Decanes	3.41	0.7788	139
Undecanes Plus	<u>19.82</u>	0.9335	387
TOTAL	100.00		

---

Heptanes Plus Properties

Heptanes Plus	44.67	0.8766	233
Undecanes Plus	19.82	0.9335	387

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 2. CONSTANT COMPOSITION  
 PRESSURE-VOLUME MEASUREMENTS

Reservoir temperature = 107°F

Saturation pressure is 1515 psia at 107°F

Thermal expansion of reservoir fluid at 5000 psia from

$$76^{\circ}\text{F} - 107^{\circ}\text{F} = \left[ \frac{\Delta V}{V \times \Delta T} \right] = 6.05 \times 10^{-4} \text{ per } ^{\circ}\text{F}$$

Compressibility of reservoir fluid at reservoir temperature:

$$\frac{1}{V_{\text{avg}}} \left[ \frac{(V_1 - V_2)}{(P_2 - P_1)} \right] \begin{array}{l} \text{from 3000 psia to 4000 psia} = 6.97 \times 10^{-6} \\ \text{from 4000 psia to 5000 psia} = 6.53 \times 10^{-6} \end{array}$$

Specific volume at saturation pressure:  $\text{ft}^3/\text{lb} = 0.02026$

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 3. PRESSURE-VOLUME RELATIONS OF RESERVOIR FLUID AT 107°F  
 (CONSTANT COMPOSITION EXPANSION)

Pressure (psia)	Relative Volume (V/V <sub>sat</sub> )*	Liquid Phase Density (gm/cm <sup>3</sup> )	Y-Function P <sub>sat</sub> - P ----- P(V/V <sub>sat</sub> - 1)	Liquid Phase Viscosity (cp)
5000	0.9739	0.8122		1.72
4000	0.9803	0.8069		1.61
3000	0.9871	0.8013		1.52
2000	0.9951	0.7948		1.44
+1515	1.0000	0.7910		1.38
1200	1.0806		3.257	1.49
900	1.2457		2.781	1.62
600	1.6618		2.304	1.72
300	3.2159		1.828	1.83
100	10.3713		1.510	2.12
15				3.25

\* Volume at pressure divided by volume at saturation pressure

+ Bubble Point Pressure

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 4. DIFFERENTIAL LIBERATION AT 107°F

Pressure (psia)	Formation Volume Factor (Bo)	Gas Volume Factor (bbl/mscf)	Gas Deviation Factor (Z = PV/NRT)	Solution Gas-Oil Ratio (scf/stb)	Liberated Gas-Oil Ratio (scf/stb)	Specific Gravity of Liberated Gas (Air = 1.0000)	Gas Viscosity* (cp)	Liquid Phase Density (gm/cm <sup>3</sup> )
5000	1.187			449	0	0.7818	0.0147	0.7910
4000	1.194			387	62	0.7933	0.0137	0.7984
3000	1.203			324	125	0.8049	0.0129	0.8049
2000	1.212			253	196	0.8143	0.0121	0.8133
+1515	1.218			170	279	0.8229	0.0113	0.8229
1200	1.194	1.983	0.833	93	356	1.0793	0.0102	0.8324
900	1.171	2.705	0.852	0	449	1.5771		0.8438
600	1.143	4.183	0.878					
300	1.110	8.767	0.920					
100	1.076	27.682	0.969					
15	1.023	190.523	1.000					

\* Calculated - Lee and Gonzalez Method

+ Bubble Point Pressure



Texaco L & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 5. HYDROCARBON ANALYSES OF LIBERATED GAS (Mole %)  
 DURING DIFFERENTIAL LIBERATION

Component	Pressure (psia)					
	1200	900	600	300	100	15
Nitrogen	9.75	7.92	3.68	1.35	0.29	0.04
Carbon Dioxide	9.97	11.23	12.97	16.23	18.71	6.44
Hydrogen Sulfide	0.85	0.99	1.34	2.14	4.42	8.27
Methane	69.23	68.80	68.20	59.86	38.68	3.86
Ethane	6.19	6.81	8.63	12.61	20.75	21.01
Propane	2.30	2.44	3.14	4.94	10.75	31.40
i-Butane	0.31	0.32	0.38	0.59	1.39	5.98
n-Butane	0.62	0.66	0.77	1.18	2.80	12.88
i-Pentane	0.17	0.19	0.21	0.29	0.69	3.36
n-Pentane	0.17	0.18	0.19	0.27	0.66	3.04
Hexanes	0.14	0.15	0.17	0.20	0.49	2.11
Heptanes Plus	0.30	0.31	0.32	0.34	0.37	1.61
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Specific Gravity (Air = 1.0000)	0.7818	0.7933	0.8143	0.8855	1.0793	1.5771
Calculated Gross Heating Value of Dry Gas at 14.65 psia and 60°F (BTU/ft <sup>3</sup> )	934	954	1029	1052	1263	2261

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst:  
 Laboratory:  
 Date:

Troupe  
 Houston  
 3-11-93

TABLE 6. SEPARATOR FLASH LIBERATION

Type of Liberation	First Stage			Gas-Oil Ratio SCF/SIB		Formation Volume Factor ( $V_{\text{sat}}/V_1$ )	Stock Tank Oil (°API at 60°F)	Separator Gas Gravity (Air = 1.0000)
	Pressure (psig)	Temperature (°F)	First Stage	Stock Tank	Total			
Flash	29	72	420	32	452	1.220	32.1	0.9897
Flash	0	72		504	504	1.252	31.4	1.1157
Differential		107			449	1.218	32.2	1.0233

-----

1 The volume of reservoir oil at the saturation pressure and temperature relative to stock tank oil at 60°F

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 7. SEPARATOR TESTS OF RESERVOIR FLUID  
 (EXPERIMENTAL DATA)  
 (1515 PSIA BUBBLE POINT FLUID)

Separator Stage	1	2
Pressure (psig)	29	0
Temperature (°F)	72	72
Gas-Oil Ratio (cfb) <sup>1</sup>	420	32
Gas Specific Gravity (Air = 1.0000)	0.9897	1.4060

Flashed Gas Analysis

Component	Mole %	Mole %
Nitrogen	3.44	0.70
Carbon Dioxide	13.23	10.64
Hydrogen Sulfide	2.92	6.01
Methane	51.09	18.31
Ethane	13.38	19.71
Propane	8.88	22.19
i-Butane	1.41	4.28
n-Butane	3.05	9.64
i-Pentane	0.81	2.72
n-Pentane	0.76	2.50
Hexanes	0.54	1.70
Heptanes Plus	0.49	1.60
TOTAL	100.00	100.00

Total Gas-Oil Ratio (cfb)..... 452  
 Stock Tank Oil Gravity (°API @ 60°F)..... 32.1  
 Bubble Point Formation Volume Factor (Vbp/Vsto)<sup>2</sup>..... 1.220

<sup>1</sup>Gas-oil ratio in cubic feet of gas at 14.65 psia and 60°F per barrel of stock tank oil at 60°F.

<sup>2</sup>Barrels of bubble point oil at 1515 psia and 107°F per barrel of stock tank oil at 60°F.

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 8. SEPARATOR TEST OF SEPARATOR FLUID  
 (EXPERIMENTAL DATA)

Separator Stage	1
Pressure (psig)	0
Temperature (°F)	72
Gas-Oil Ratio (cfb) <sup>1</sup>	504
Gas Specific Gravity (Air = 1.0000)	1.1157

Flashed Gas Analysis

<u>Component</u>	<u>Mole %</u>
Nitrogen	2.89
Carbon Dioxide	12.06
Hydrogen Sulfide	3.15
Methane	45.38
Ethane	12.89
Propane	10.29
i-Butane	2.04
n-Butane	5.00
i-Pentane	1.73
n-Pentane	1.72
Hexanes	1.45
Heptanes Plus	<u>1.40</u>
TOTAL	100.00

Total Gas-Oil Ratio (cfb)..... 504  
 Stock Tank Oil Gravity (°API @ 60°F)..... 31.4  
 Bubble Point Formation Volume Factor (V<sub>bp</sub>/V<sub>sto</sub>)<sup>2</sup>..... 1.252

<sup>1</sup>Gas-oil ratio in cubic feet of gas at 14.65 psia and 60°F per barrel of stock tank oil at 60°F.

<sup>2</sup>Barrels of bubble point oil at 1515 psia and 107°F per barrel of stock tank oil at 60°F.

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 9. HYDROCARBON ANALYSES OF SEPARATOR PRODUCTS  
 AND CALCULATED WELLSTREAM  
 (450 GOR FLUID)

<u>Component</u>	<u>Separator Oil</u> <u>Mole %</u>	<u>Separator Gas</u> <u>Mole %</u> <u>GPM</u>	<u>Wellstream</u> <u>Mole %</u>
Nitrogen	0.02	3.65	1.61
Carbon Dioxide	0.33	12.92	5.83
Hydrogen Sulfide	0.40	3.12	1.59
Methane	0.60	51.17	22.69
Ethane	1.02	12.89	6.20
Propane	2.56	8.92    2.458	5.34
i-Butane	0.99	1.50    0.491	1.21
n-Butane	3.56	3.32    1.048	3.46
i-Pentane	2.66	0.89    0.325	1.89
n-Pentane	3.56	0.82    0.297	2.36
Hexanes	7.71	0.52    0.214	4.57
Heptanes Plus	<u>76.59</u>	<u>0.28</u> <u>0.133</u>	<u>43.25</u>
TOTAL	100.00	100.00    4.966	100.00

-----  
 . Heptanes Plus Properties (Separator Oil)

Specific Gravity @ 60/60°F = 0.878	0.739	0.847
Molecular Weight = 234	114	223

. Separator Gas Properties

Calculated Gravity (Air = 1.0000) = 0.9861  
 Calculated Gross Heating Value = 1257 BTU/ft<sup>3</sup> of Dry Gas @ 14.65 psia and 60°F  
 Molecular Weight = 28.6

. Gas-Oil Production Ratios Used For Study

Primary Separator Gas/Separator Oil Ratio = 445 SCF/BBL  
 Primary Separator Oil/Stock Tank Oil Ratio = 1.0110 BBL/STB @ 60°F  
 Primary Separator Gas/Stock Tank Oil Ratio = 450 SCF/STB @ 60°F

. Stock Tank Oil Properties

API Gravity @ 60°F = 33.5  
 Specific Gravity @ 60/60°F = 0.8574

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 10. CONSTANT COMPOSITION  
 PRESSURE-VOLUME MEASUREMENTS  
 (450 GOR FLUID)

Reservoir temperature = 107°F

Saturation pressure is 1725 psia at 107°F

Thermal expansion of reservoir fluid at 5000 psia from

$$76^{\circ}\text{F} - 107^{\circ}\text{F} = \left[ \frac{\Delta V}{V \times \Delta T} \right] = 5.287 \times 10^{-4} \text{ per } ^{\circ}\text{F}$$

Compressibility of reservoir fluid at reservoir temperature:

$$\frac{1}{V_{\text{avg}}} \left[ \frac{(V_1 - V_2)}{(P_2 - P_1)} \right] \text{ from 4000 psia to 5000 psia} = 6.510 \times 10^{-6}$$

Specific volume at saturation pressure:  $\text{ft}^3/\text{lb} = 0.02021$

Texaco E & P Inc.  
 Bob Slaughter Blk. #152 Well  
 Slaughter Field  
 Hockley County, Texas

Analyst: Troupe  
 Laboratory: Houston  
 Date: 3-11-93

TABLE 11. PRESSURE-VOLUME RELATIONS OF RESERVOIR FLUID AT 107°F  
 (CONSTANT COMPOSITION EXPANSION)  
 (450 GOR FLUID)

Pressure (psia)	Relative Volume (V/V <sub>sat</sub> )*	Liquid Phase <sup>+</sup> Density (gm/cm <sup>3</sup> )	Y-Function P <sub>sat</sub> - P ----- P(V/V <sub>sat</sub> - 1)
5000	0.9767	0.8120	
4000	0.9831	0.8068	
3000	0.9900	0.8011	
+ 1725	1.0000	0.7931	
1510	1.0382		3.731
1463	1.0484		3.697
1383	1.0691		3.579
1314	1.0898		3.484
1283	1.1001		3.440
1229	1.1209		3.338
1179	1.1417		3.269
1058	1.2041		3.088
808	1.4130		2.748

\* Volume at pressure divided by volume at saturation pressure

+ Bubble Point Pressure

FIGURE 1 RELATIVE VOLUME VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER

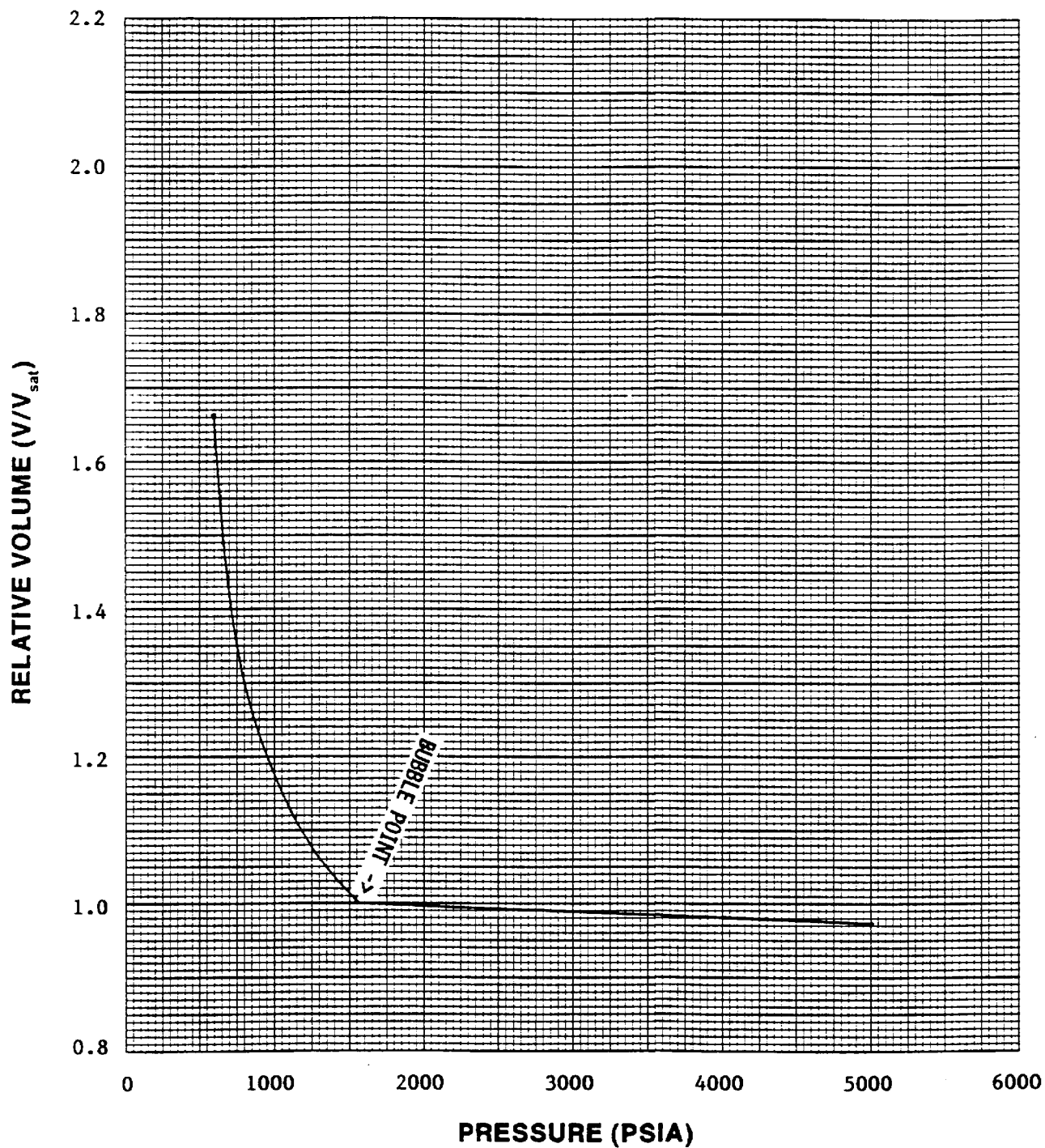
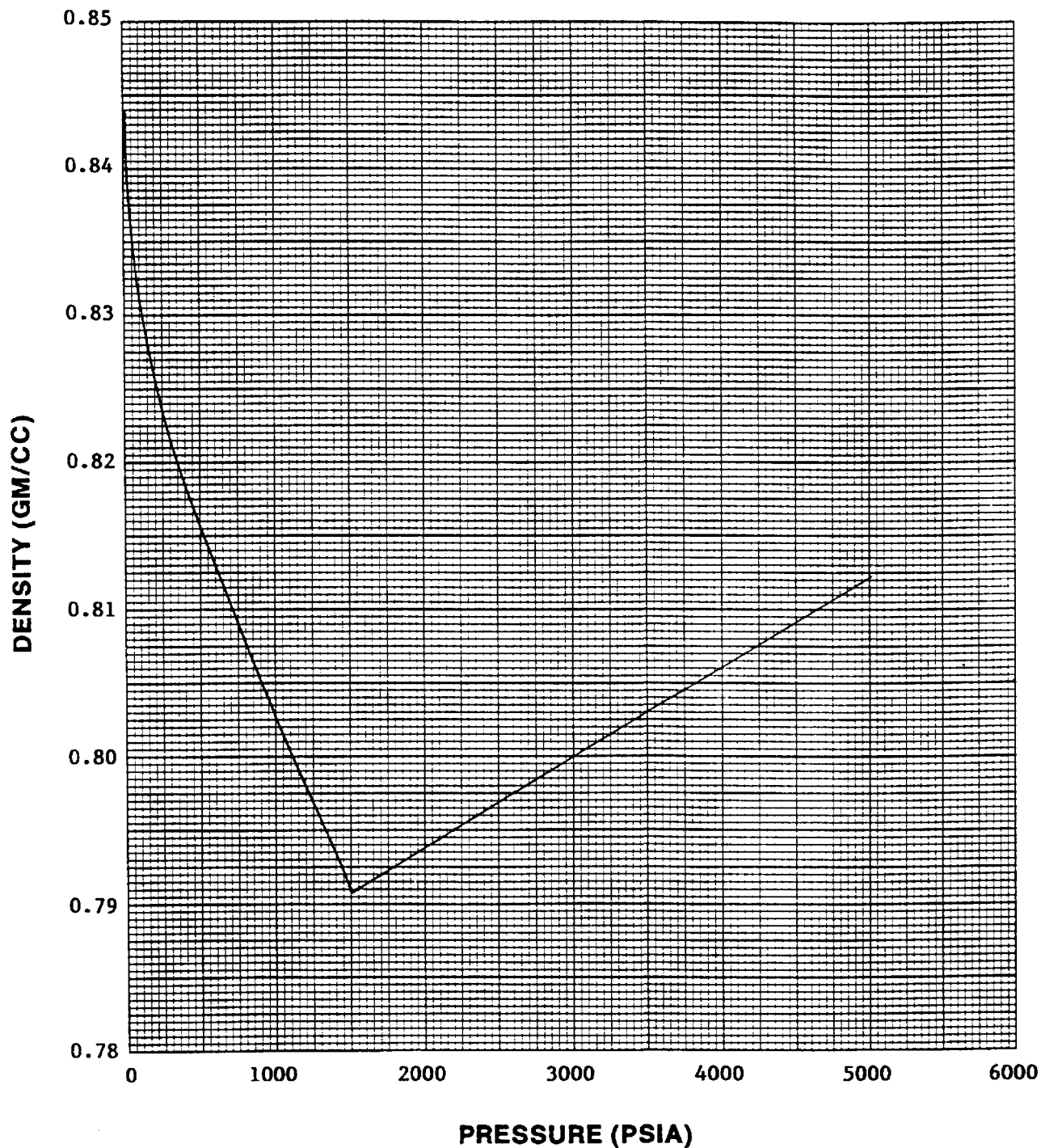




FIGURE 2 DENSITY VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER



**FIGURE 3 VISCOSITY VERSUS PRESSURE AT 107 °F**

**COMPANY:** TEXACO E & P INC.  
**ANALYST:** TROUPE  
**LOCATION:** HOCKLEY COUNTY, TEXAS

**DATE:** 3-11-93  
**WELL:** BOB SLAUGHTER BLK. #152  
**FIELD:** SLAUGHTER

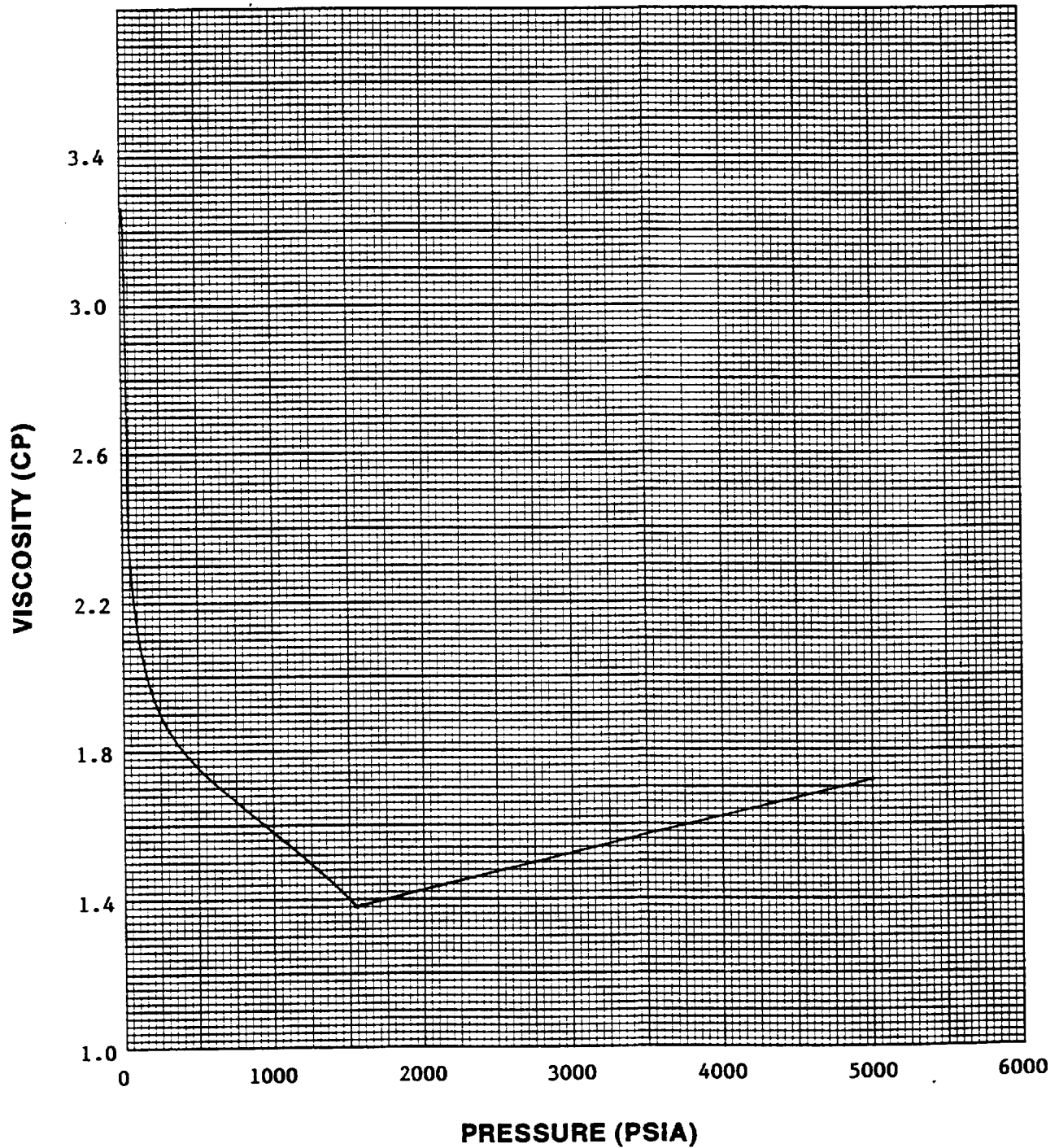


FIGURE 4 FORMATION VOLUME FACTOR VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER

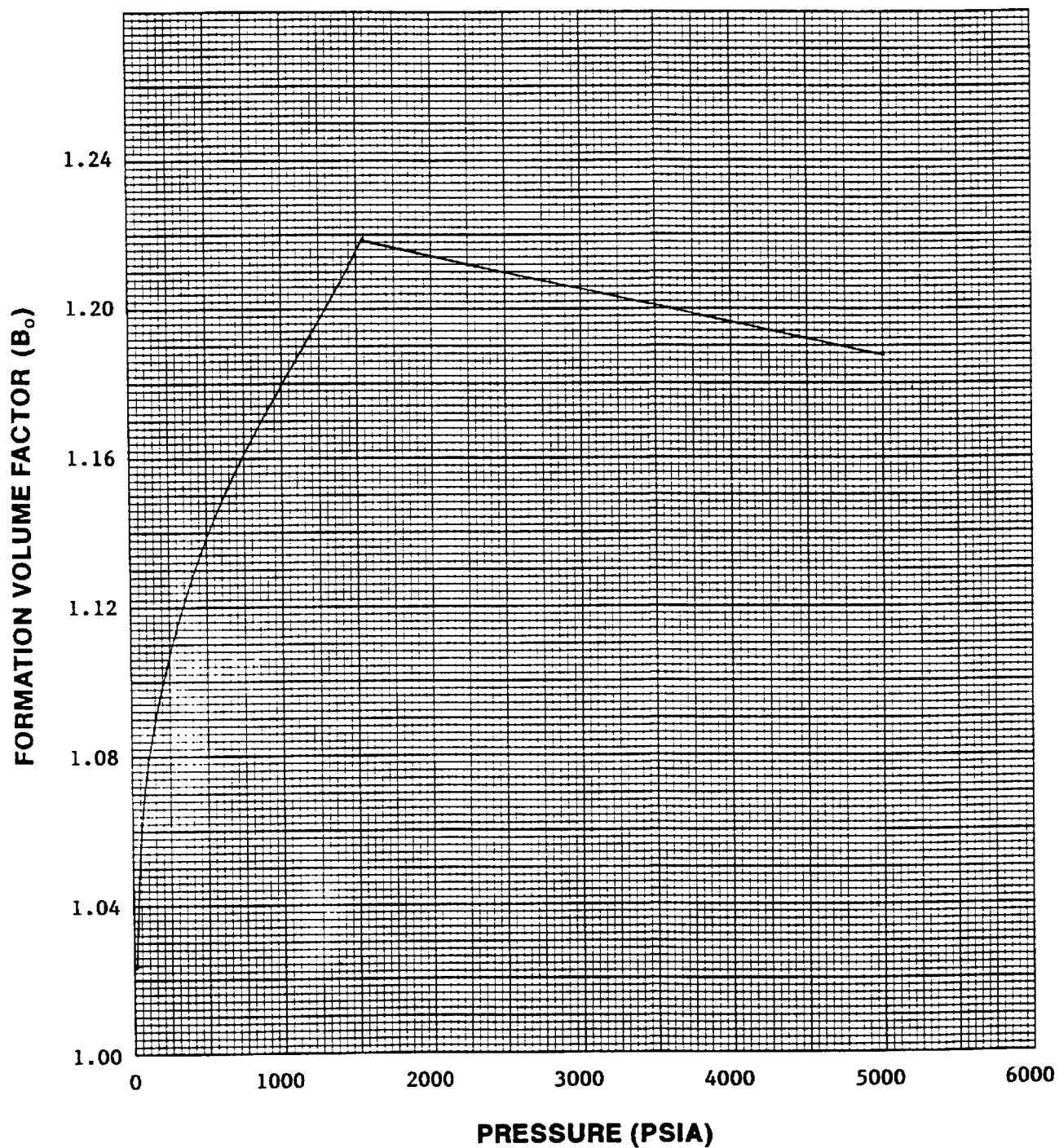


FIGURE 5 GAS DEVIATION FACTOR VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER

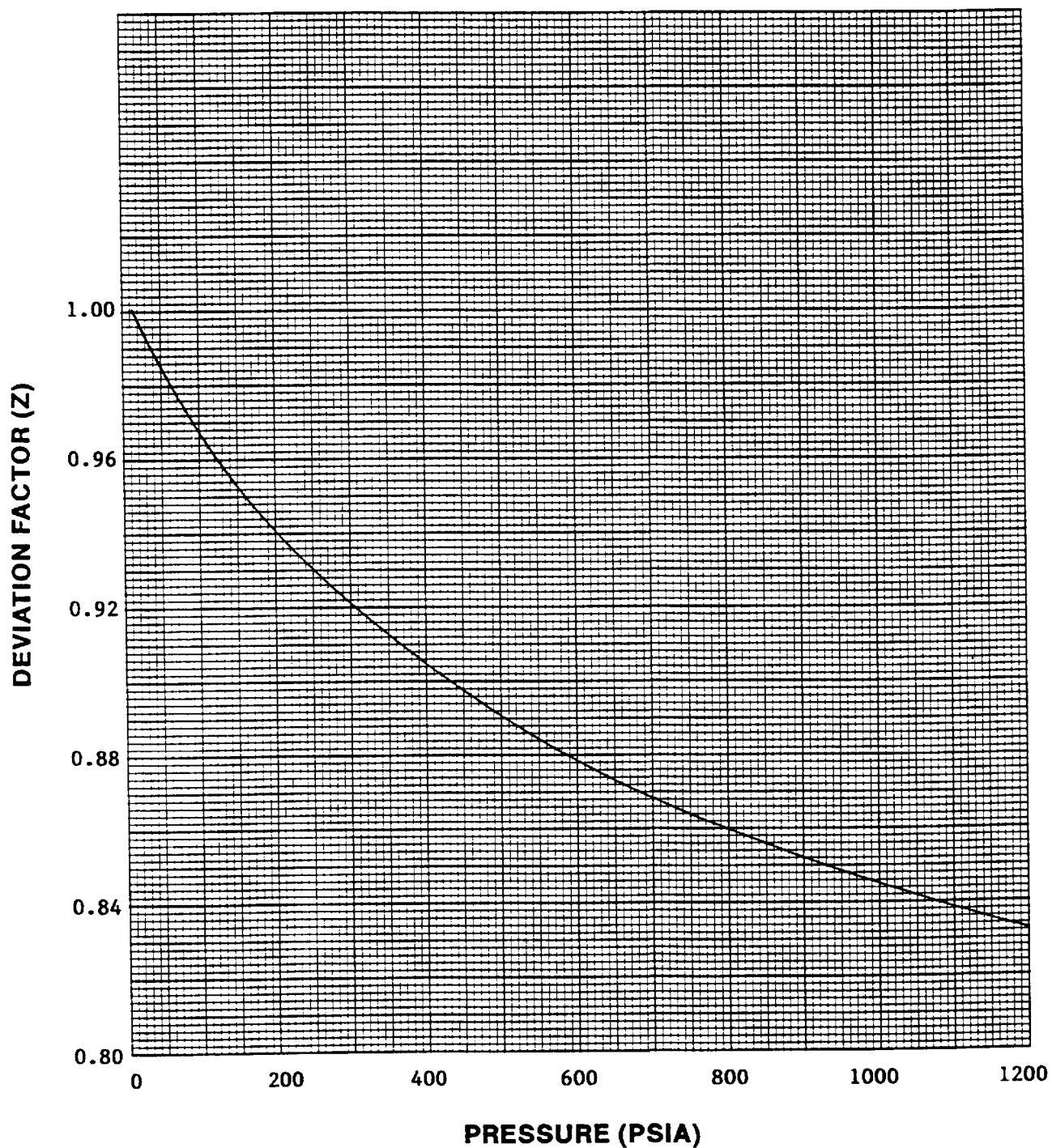


FIGURE 6 SOLUTION GAS-OIL RATIO VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER

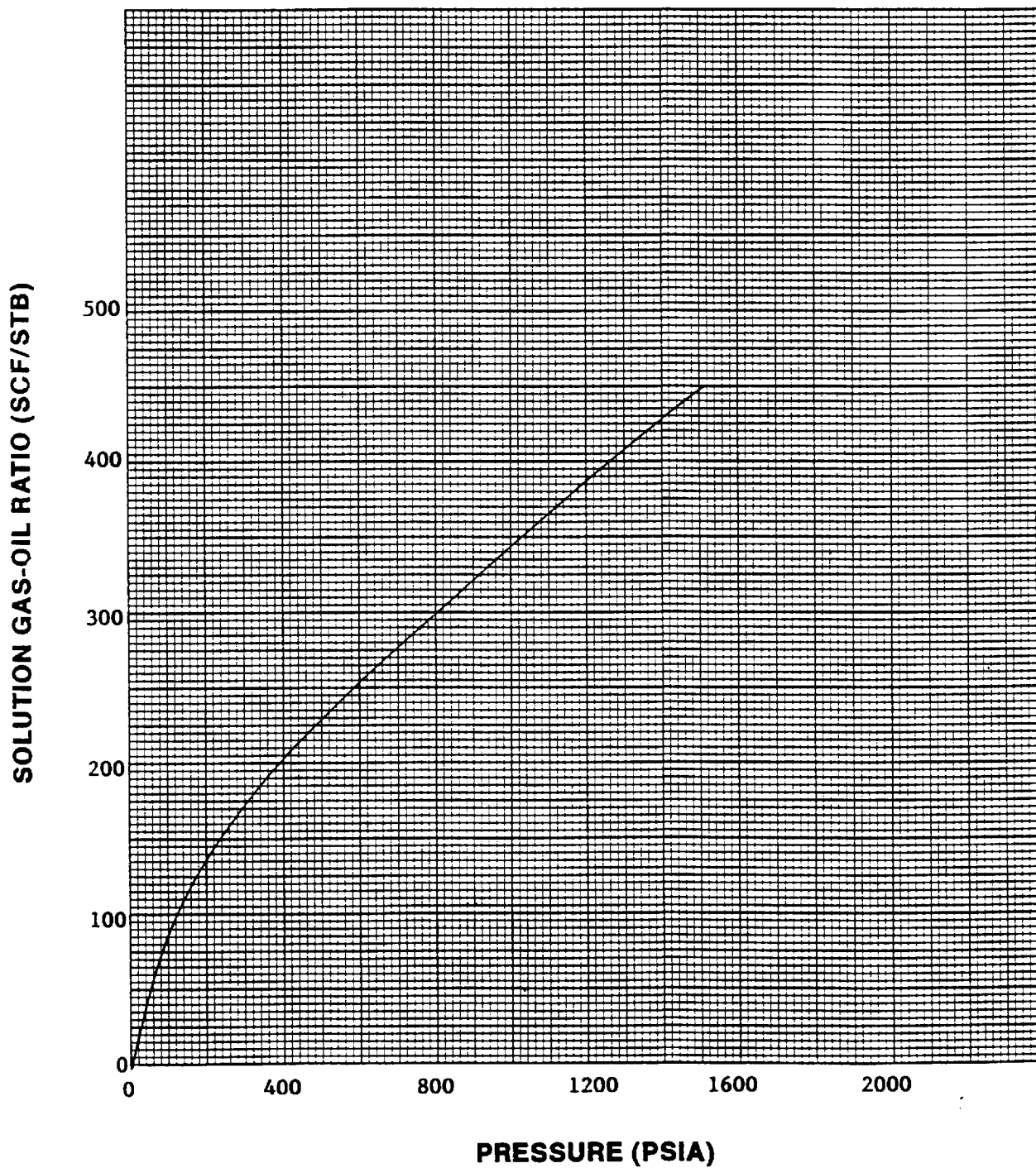


FIGURE 7 LIBERATED GAS-OIL RATIO VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER

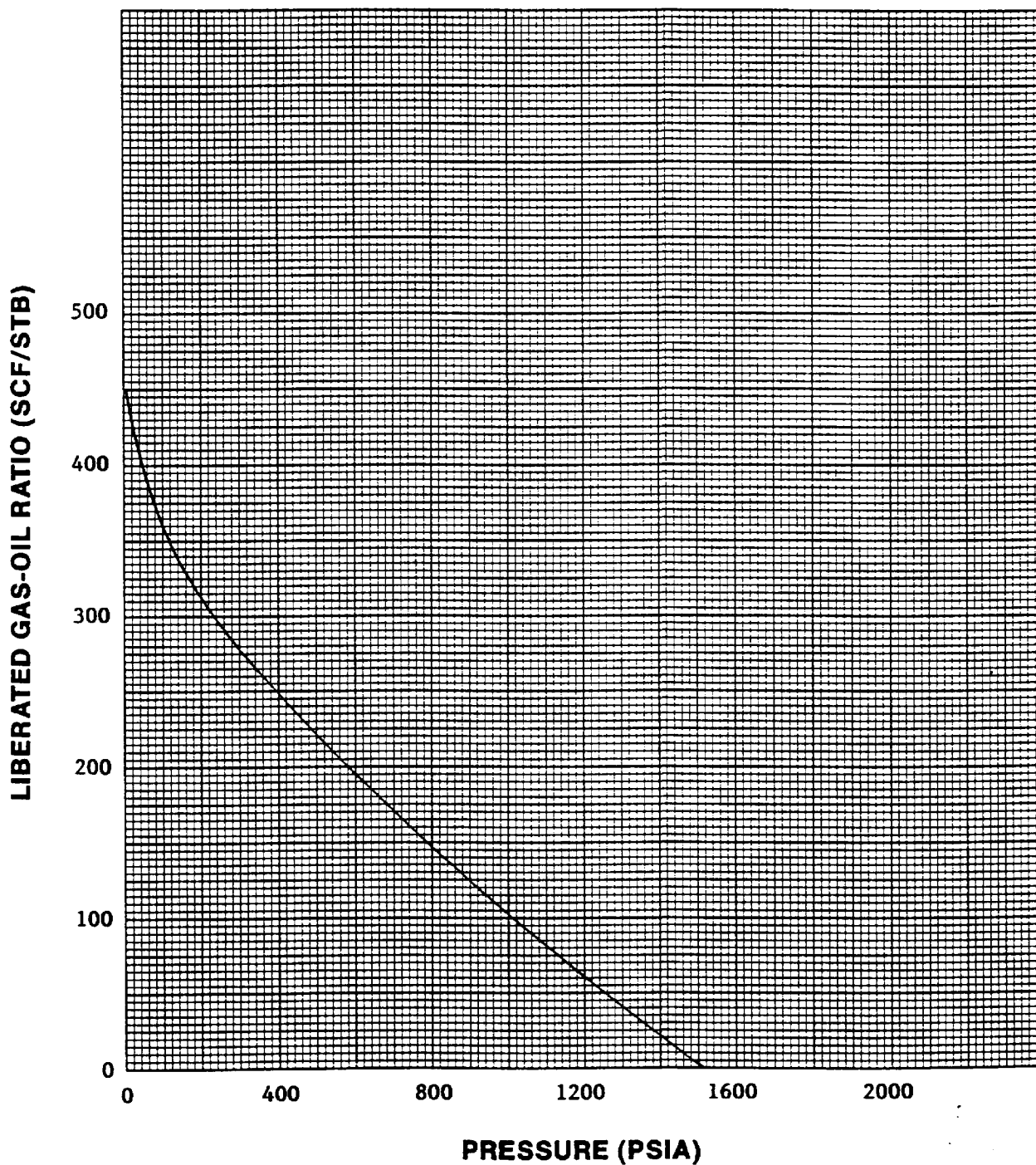


FIGURE 8 GAS VISCOSITY VERSUS PRESSURE AT 107 °F

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER

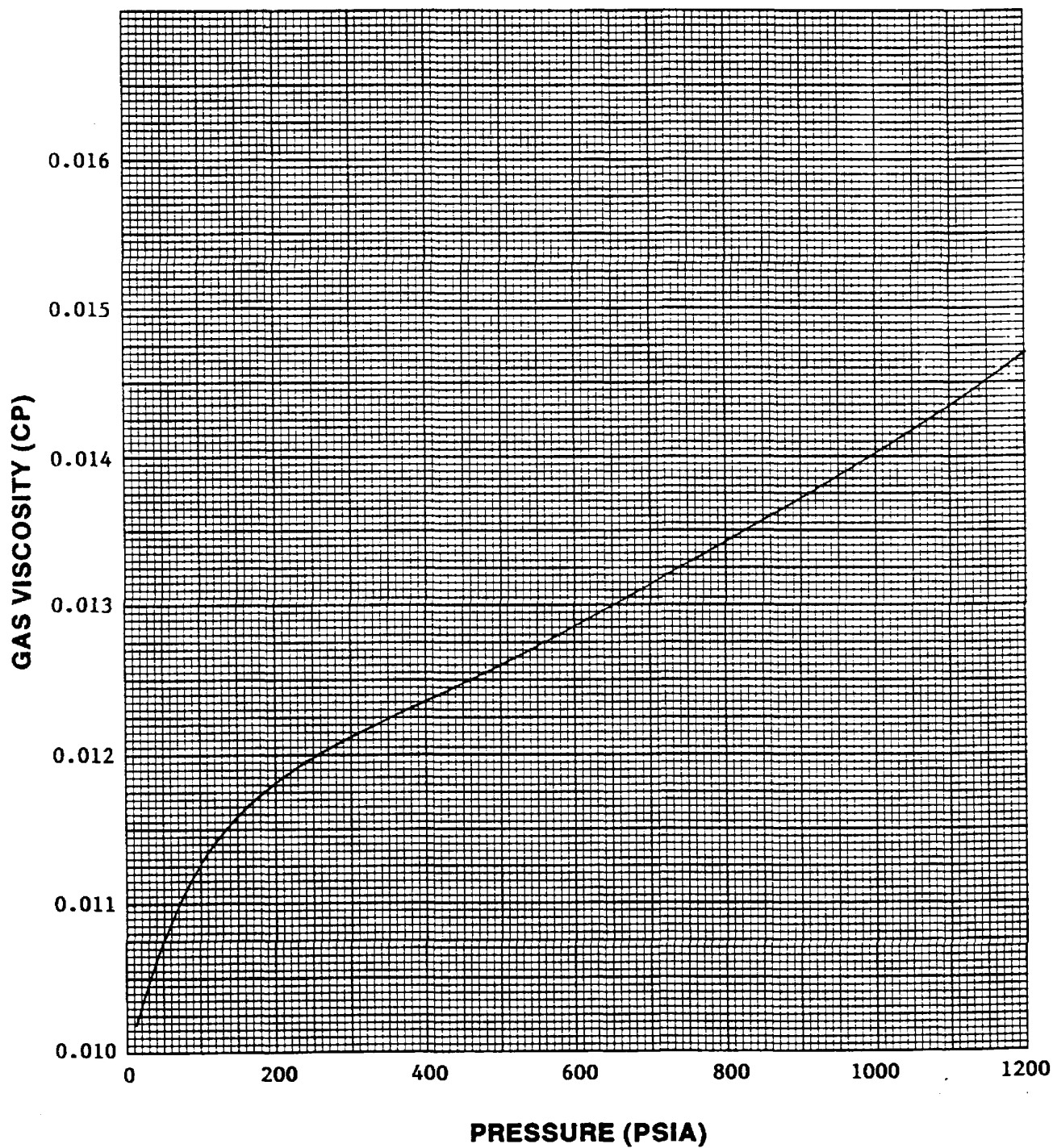
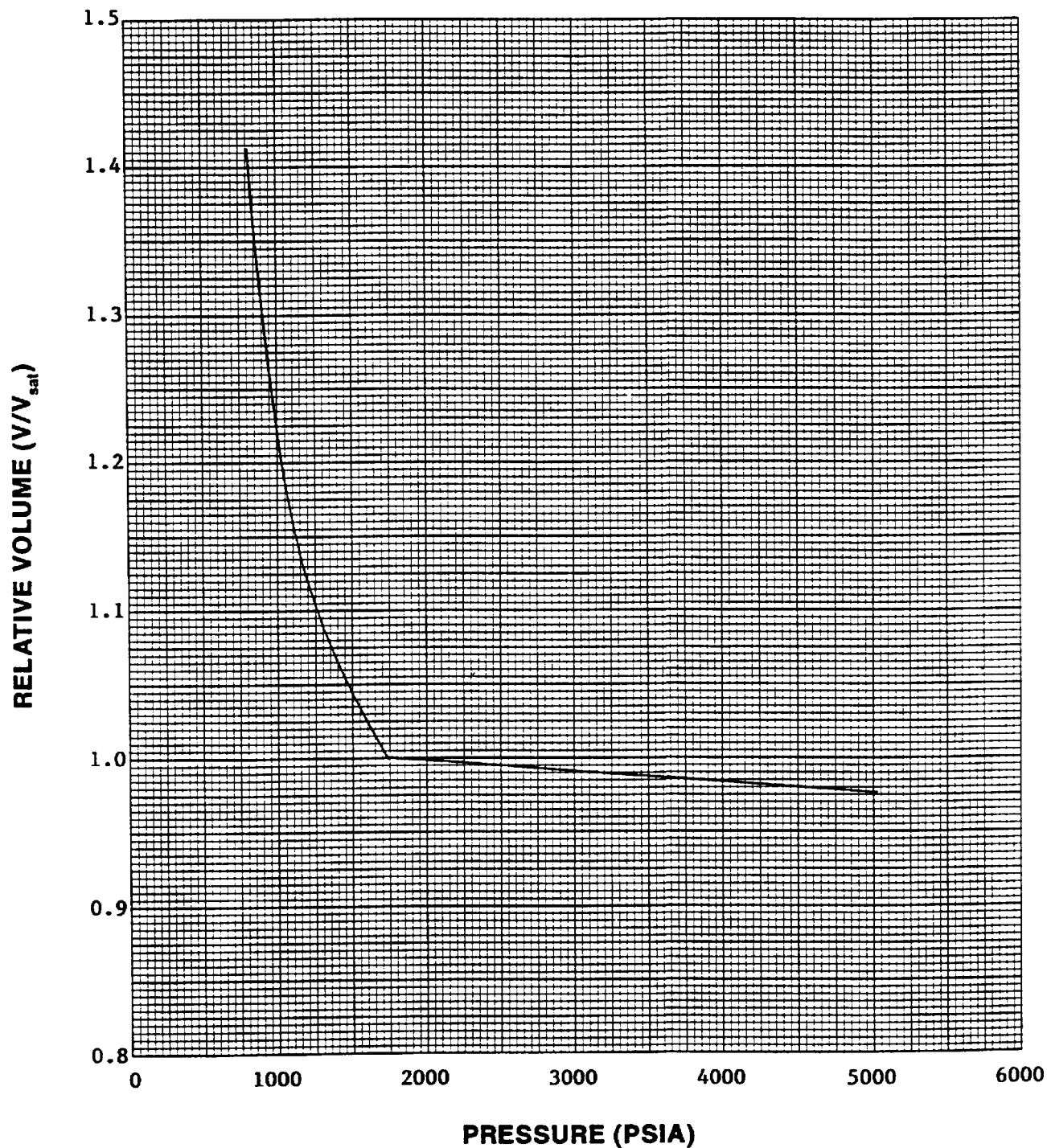




FIGURE 9 RELATIVE VOLUME VERSUS PRESSURE AT 107 °F  
450 GOR FLUID

COMPANY: TEXACO E & P INC.  
ANALYST: TROUPE  
LOCATION: HOCKLEY COUNTY, TEXAS

DATE: 3-11-93  
WELL: BOB SLAUGHTER BLK. #152  
FIELD: SLAUGHTER





UNIVERSAL TREATING COMPANY

WATER ANALYSIS

Company: TEXACO Date: 9-13-90

Lease: BSB Well #: 345

Wellhead Alkalinity = 639 mg/l  
Total Hardness = 10,287 mg/l  
Wellhead pH = 6.47  
Resistivity = 0.0750 ohm-meters  
Specific Gravity = 1.065  
Total Dissolved Solids = 92,690 mg/l  
Sodium (Na) = 23,959 mg/l  
Calcium (Ca) = 8,100 mg/l  
Magnesium (Mg) = 2,187 mg/l  
Iron (Fe) = 0.6 mg/l  
Chloride (Cl) = 56,062 mg/l  
Bicarb. (HCO<sub>3</sub>) = 639 mg/l  
Sulfate (SO<sub>4</sub>) = 1,742 mg/l  
Carbonate Scaling Tendency: 0.55  
Sulfate Scaling Tendency: 8.52

Comments: \_\_\_\_\_

UNIVERSAL TREATING COMPANY

WATER ANALYSIS

Company: TEXACO Date: 9-13-90

Lease: BSB Well #: 354

Wellhead Alkalinity = 605 mg/l  
Total Hardness = 10,511 mg/l  
Wellhead pH = 6.42  
Resistivity = 0.0750 ohm-meters  
Specific Gravity = 1.065  
Total Dissolved Solids = 92,780 mg/l  
Sodium (Na) = 23,793 mg/l  
Calcium (Ca) = 8,421 mg/l  
Magnesium (Mg) = 2,090 mg/l  
Iron (Fe) = 0.6 mg/l  
Chloride (Cl) = 56,062 mg/l  
Bicarb. (HCO<sub>3</sub>) = 605 mg/l  
Sulfate (SO<sub>4</sub>) = 1,809 mg/l  
Carbonate Scaling Tendency: 0.50  
Sulfate Scaling Tendency: 10.81

Comments: \_\_\_\_\_

UNIVERSAL TREATING COMPANY

WATER ANALYSIS

Company: Texaco, Inc. Date: Aug. 01, 1990  
Lease: Bob Slaughter Block Well #: 332  
Battery 11

Wellhead Alkalinity = 466 mg/l  
Total Hardness = 12,280 mg/l  
Wellhead pH = 6.00  
Resistivity = 0.0643 ohm-meters  
Specific Gravity = 1.075  
Total Dissolved Solids = 109,919 mg/l  
Sodium (Na) = 28,420 mg/l  
Calcium (Ca) = 9,704 mg/l  
Magnesium (Mg) = 2,576 mg/l  
Iron (Fe) = 0.3 mg/l  
Chloride (Cl) = 67,074 mg/l  
Bicarb. (HCO<sub>3</sub>) = 466 mg/l  
Sulfate (SO<sub>4</sub>) = 1,679 mg/l  
Carbonate Scaling Tendency: 0.10  
Sulfate Scaling Tendency: 10.16

Comments: \_\_\_\_\_  
\_\_\_\_\_

Meter: 228603  
 Name: BOB SLAUGHTER - BATT 2,3  
 Buyer: AMOCO PRODUCTION COMPANY  
 Seller: TEXACO INC  
 Meter Oper.: AMOCO PRODUCTION COMPANY

Effective Date: 01/01/98 00:00:00  
 Revision Date: 01/01/98 00:00:00  
 Tester: NEIL SMITH  
 Witness:  
 Operations Center: SLAUGHTER

#### SAMPLE INFORMATION

Valid Record: Y  
 Date Sampled: 12/08/97 00:00:00  
 Analyzed: 12/12/97 00:00:00  
 Typification ID: NONE  
 Level: C6+  
 Data Source: Laboratory  
 Cylinder ID: RC1325  
 Sample Pressure: 6.000 Psi  
 Temperature: 0.000 F  
 Base Pressure: 14.65 Psi  
 Temperature: 60.00 F  
 Analysis Performed By:

BA Code: 517785 Addr. Sub: 01

PANTECHS LABORATORIES  
 4912 Homestead  
 Lubbock, TX 79424  
 806-797-43265  
 -  
 -

#### CHROMATOGRAPH RESULTS

Component		Mole %	GPM
Methane	C1	41.4848	
Ethane	C2	14.4564	3.8762
Propane	C3	12.1221	3.3487
i-Butane	iC4	2.1090	0.6917
n-Butane	nC4	5.0316	1.5904
i-Pentane	iC5	1.4743	0.5411
n-Pentane	nC5	1.4580	0.5294
Hexane	C6	2.3786	1.0236
Heptane	C7	0.0000	0.0000
Octane	C8	0.0000	0.0000
Nonane	C9	0.0000	0.0000
Decane	C10	0.0000	0.0000
Argon	AR	0.0000	
Carbon D.	CO2	12.5218	
Carbon M.	CO	0.0000	
Helium	HE	0.0000	
Hydrogen	H	0.0000	
H. Sulfide	H2S	3.8000	
Nitrogen	N2	3.1634	
Oxygen	O2	0.0000	
Water	H2O	0.0000	

#### CALCULATED RESULTS

	Dry	Sat.
Ideal BTU:	1474.06	1449.15
Real BTU:	1485.86	1461.44
Specific Gravity:	1.1337	1.1254
Molecular Weight:	32.5856	32.3306
Compressibility:	0.9921	0.9916
Wobbe Index:	1395.50	

Calculated Source: Original

	GPM
Decane and Heavier:	0.0000
Nonane and Heavier:	0.0000
Octane and Heavier:	0.0000
Heptane and Heavier:	0.0000
Hexane and Heavier:	1.0236
Pentanes and Heavier:	2.0941
Butanes and Heavier:	4.3762
Propanes and Heavier:	7.7249
Ethanes and Heavier:	11.6011
26# RVP Gasoline:	3.2192

#### REMARKS

**SLAUGHTER**

**CORE**

**DATABASE**

**INFORMATION**

**CORE LABORATORIES, INC.**  
*Petroleum Reservoir Engineering*  
DALLAS, TEXAS

**CORE ANALYSIS REPORT**

**FOR**

**TEXACO, INC.**

**BOB SLAUGHTER BLOCK 329  
SLAUGHTER FIELD  
HOCKLEY COUNTY, TEXAS**

**PRELIMINARY PRINT**

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees assume no responsibility and make no warranty or representations, as to the productivity, proper operations, or profitability of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

**CORE LABORATORIES, INC.**  
*Petroleum Reservoir Engineering*  
DALLAS, TEXAS

PAGE 1 OF

TEXACO, INC.  
BOB SLAUGHTER BLOCK 329  
SLAUGHTER FIELD  
HOCKLEY COUNTY, TEXAS

DATE : 1-24-81  
FORMATION : SAN ANDRES  
IRLG. FLUID: BRINE  
LOCATION : 900' FSL & 1250' FWL, LGE. 39, LAB. 62, MAVERICK CSL SUR

FILE NO : 3202-12123  
ANALYSTS : REINHEIMER  
LABORATORY: MIDLAND TEXAS

FULL DIAMETER ANALYSIS

SAMPLE NUMBER	DEPTH FEET	PERM MAXIMUM	PERM 90 DEG	PERM VERTICAL	HE FOR	OIL% FORE	WTR% FORE	GRAIN DEN	DESCRIPTION
------------------	---------------	-----------------	----------------	------------------	-----------	--------------	--------------	--------------	-------------

CORE NO. 1 4930.0-4990.0 CUT 60' REC 60'

1	4930.0-31.0	0.3	<0.1	<0.1	5.8	11.8	50.5	2.84	DOL ANHY SL/SHY SHLAM
2	4931.0-32.0	0.7	0.5	0.2	8.5	27.3	29.5	2.86	DOL SL/ANHY SL/SHY
3	4932.0-33.0	0.3	0.2	0.1	8.8	4.3	56.4	2.83	DOL SL/ANHY SHLAM
4	4933.0-34.0	<0.1	<0.1	<0.1	6.9	18.8	58.0	2.84	DOL SL/ANHY SL/F SHLAM
5	4934.0-35.0	<0.1	<0.1	<0.1	8.0	14.1	59.0	2.86	DOL SL/ANHY
6	4935.0-36.0	0.1	<0.1	0.2	4.5	5.4	75.7	2.88	DOL SL/ANHY
7	4936.0-37.0	<0.1	<0.1	<0.1	1.8	0.0	81.5	2.88	DOL ANHY
8	4937.0-38.0	<0.1	<0.1	<0.1	2.2	0.0	93.7	2.90	DOL ANHY
9	4938.0-39.0	<0.1	<0.1	<0.1	2.5	0.0	97.6	2.87	DOL SL/ANHY
10	4939.0-40.0	0.3	0.2	<0.1	1.3	0.0	88.9	2.93	ANH DOLC SHLAM
11	4940.0-41.0	<0.1	<0.1	<0.1	1.5	0.0	78.6	2.95	ANH DOLC
12	4941.0-42.0	<0.1	<0.1	<0.1	0.8	0.0	80.0	2.95	ANH DOLC
13	4942.0-43.0	0.2	<0.1	<0.1	2.3	0.0	97.2	2.91	DOL V/ANHY
14	4943.0-44.0	<0.1	<0.1	<0.1	2.5	11.8	85.3	2.89	DOL ANHY
15	4944.0-45.0	2.0	<0.1	0.2	2.1	0.0	94.1	2.87	DOL ANHY VF
16	4945.0-46.0	<0.1	<0.1	<0.1	2.7	0.0	90.6	2.88	DOL ANHY STY
17	4946.0-47.0	<0.1	<0.1	<0.1	2.5	5.7	91.4	2.88	DOL ANHY
18	4947.0-48.0	<0.1	<0.1	0.1	2.3	0.0	96.2	2.87	DOL ANHY SHLAM
19	4948.0-49.0	<0.1	<0.1	0.1	2.6	0.0	97.1	2.87	DOL SL/ANHY
20	4949.0-50.0	<0.1	<0.1	0.1	2.7	5.0	87.5	2.89	DOL ANHY
21	4950.0-51.0	<0.1	<0.1	<0.1	4.2	0.0	92.3	2.87	DOL SL/ANHY SHLAM
22	4951.0-52.0	<0.1	<0.1	<0.1	4.3	0.0	78.9	2.87	DOL SL/ANHY SHLAM
23	4952.0-53.0	0.5	0.3	<0.1	7.4	28.4	33.3	2.84	DOL SL/ANHY SHLAM STY
24	4953.0-54.0	2.1	1.5	<0.1	11.2	34.2	29.7	2.83	DOL SL/ANHY VF

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, minor operations or profitability of any well or other interest in all or part of the formation described herein.

**CORE LABORATORIES, INC.**  
*Petroleum Reservoir Engineering*

DALLAS, TEXAS

TEXACO, INC.  
 BOB SLAUGHTER BLOCK 329

DATE : 1-24-81  
 FORMATION : SAN ANDRES

FILE NO : 3202-12123  
 ANALYSTS : REINHEIMER

## FULL DIAMETER ANALYSIS

SAMPLE NUMBER	DEPTH FEET	PERM MAXIMUM	PERM 90 DEG	PERM VERTICAL	HE FOR	OIL% PORE	WTR% PORE	GRAIN DEN	DESCRIPTION
25	4954.0-55.0	1.0	0.9	0.2	10.6	23.8	25.4	2.88	DOL SL/ANHY
26	4955.0-56.0	0.5	0.4	<0.1	9.2	29.0	22.1	2.86	DOL SL/ANHY
27	4956.0-57.0	0.7	0.7	<0.1	10.9	30.5	21.4	2.85	DOL SL/ANHY
28	4957.0-58.0	0.8	0.6	<0.1	10.2	31.0	24.1	2.86	DOL SL/ANHY SL/F
29	4958.0-59.0	1.3	1.1	<0.1	13.5	37.7	25.3	2.86	DOL SL/ANHY SL/SIDY VF SHLAM
30	4959.0-60.0	1.2	1.1	<0.1	11.9	30.2	20.5	2.86	DOL SL/ANHY SL/SIDY
31	4960.0-61.0	<0.1	<0.1	<0.1	2.9	30.2	47.2	2.92	DOL ANHY SHLAM
32	4961.0-62.0	<0.1	<0.1	<0.1	1.8	8.3	62.5	2.93	DOL V/ANHY
33	4962.0-63.0	<0.1	<0.1	<0.1	1.7	0.0	76.2	2.94	DOL V/ANHY
34	4963.0-64.0	0.2	0.1	<0.1	3.4	11.1	75.0	2.91	DOL V/ANHY SL/SHY SHLAM
35	4964.0-65.0	1.1	0.8	<0.1	5.8	40.5	24.1	2.90	DOL SL/ANHY
36	4965.0-66.0	4.5	4.0	0.2	16.8	48.8	19.9	2.87	DOL SL/ANHY STY
37	4966.0-67.0	0.5	0.5	<0.1	11.4	31.2	30.6	2.86	DOL SL/ANHY
38	4967.0-68.0	1.3	1.3	<0.1	9.5	26.0	41.1	2.80	DOL SL/ANHY SL/CHTY SL/F
39	4968.0-69.0	2.3	2.2	<0.1	12.6	31.6	35.1	2.84	DOL SL/ANHY STY
40	4969.0-70.0	4.3	3.6	<0.1	13.8	23.6	48.2	2.83	DOL SL/ANHY
41	4970.0-71.0	6.2	5.6	0.5	13.9	23.7	39.5	2.85	DOL SL/ANHY
42	4971.0-72.0	3.7	3.1	<0.1	8.7	40.3	23.4	2.89	DOL ANHY
43	4972.0-73.0	1.8	1.7	0.2	9.9	32.0	26.6	2.85	DOL SL/ANHY
44	4973.0-74.0	0.7	0.6	<0.1	10.0	38.6	26.7	2.85	DOL SL/ANHY
45	4974.0-75.0	2.3	1.8	0.2	12.5	43.1	24.5	2.85	DOL SL/ANHY SL/SIDY
46	4975.0-76.0	3.2	3.1	0.4	12.3	26.6	38.3	2.84	DOL SL/ANHY SL/SIDY SL/SHY
47	4976.0-77.0	4.4	4.0	0.8	15.7	38.2	26.5	2.85	SL/F PF SHLAM
48	4977.0-78.0	0.4	0.3	0.2	11.6	50.4	21.5	2.84	DOL SL/ANHY SL/SIDY PF
49	4978.0-79.0	<0.1	<0.1	0.8	7.1	26.9	52.8	2.85	DOL SL/ANHY SL/SIDY SL/SHY PF
* 50	4979.0-80.0	0.3			10.9	17.8	47.9	2.80	SHLAM
51	4980.0-81.0	<0.1	<0.1	0.1	7.4	19.3	55.4	2.87	DOL SL/ANHY VF SHLAM
52	4981.0-82.0	<0.1	<0.1	0.1	8.5	19.0	62.9	2.88	DOL SL/ANHY SL/SIDY PF FOSS

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**CORE LABORATORIES, INC.**  
*Petroleum Reservoir Engineering*  
DALLAS, TEXAS

PAGE 3 OF

TEXACO, INC.  
BOB SLAUGHTER BLOCK 329

DATE : 1-24-81  
FORMATION : SAN ANDRES

FILE NO : 3202-12123  
ANALYSTS : REINHHEIMER

**FULL DIAMETER ANALYSIS**

SAMPLE NUMBER	DEPTH FEET	PERM MAXIMUM	PERM 90 DEG	PERM VERTICAL	HE FOR	OIL% FORE	WTR% FORE	GRAIN DEN	DESCRIPTION
53	4982.0-83.0	1.3	1.3	<0.1	9.3	29.6	33.6	2.86	DOL SL/ANHY PF SHLAM FOSS
54	4983.0-84.0	1.8	1.8	0.1	11.4	25.3	26.6	2.84	DOL SL/ANHY PF
55	4984.0-85.0	1.7	1.2	<0.1	11.2	25.6	38.4	2.85	DOL SL/ANHY PF SHLAM
56	4985.0-86.0	0.6	0.4	0.2	8.7	32.3	28.3	2.85	DOL SL/ANHY PF
57	4986.0-87.0	0.8	0.8	0.2	8.5	32.4	37.8	2.86	DOL SL/ANHY SL/STY PF
58	4987.0-88.0	0.1	<0.1	0.3	4.9	13.7	70.6	2.86	DOL SL/ANHY PF
59	4988.0-89.0	0.1	0.2	0.2	7.3	17.2	54.7	2.85	DOL SL/ANHY PF
60	4989.0-90.0	2.0	0.4	0.2	8.8	20.4	57.5	2.84	DOL SL/ANHY PF SHLAM

CORE NO. 2 4990.0-5050.0 CUT 60' REC 61'

61	4990.0-91.0	6.5	5.9	8.3	13.6	14.5	40.3	2.86	DOL SL/ANHY PF STY
62	4991.0-92.0	35.	30.	28.	17.8	15.3	53.1	2.82	DOL SL/ANHY SL/CHTY PF
63	4992.0-93.0	14.	13.	1.4	14.3	16.5	57.2	2.81	DOL SL/ANHY SL/CHTY PF
64	4993.0-94.0	7.0	6.6	4.2	13.1	20.1	47.8	2.82	DOL SL/ANHY SL/CHTY SL/F ST
65	4994.0-95.0	11.	11.	11.	17.4	25.5	42.7	2.83	DOL SL/ANHY SL/CHTY VF
66	4995.0-96.0	7.1	5.5	3.6	14.7	25.1	37.4	2.85	DOL SL/ANHY STY
67	4996.0-97.0	2.4	2.2	0.7	12.0	19.5	36.4	2.84	DOL SL/ANHY PF
68	4997.0-98.0	0.7	0.4	<0.1	8.8	27.0	28.9	2.83	DOL SL/ANHY PF SHLAM
69	4998.0-99.0	0.4	0.3	<0.1	8.3	23.2	47.4	2.82	DOL SL/ANHY SL/F PF
70	4999.0-0.0	1.6	1.4	<0.1	11.7	32.1	30.5	2.81	DOL SL/ANHY
71	5000.0-1.0	9.0	6.7	0.1	11.7	32.1	30.5	2.81	DOL SL/ANHY
72	5001.0-2.0	5.3	4.8	1.6	12.0	20.2	28.7	2.85	DOL SL/ANHY PF
73	5002.0-3.0	<0.1	4.8	3.1	14.0	17.4	29.2	2.85	DOL SL/ANHY SL/F PF
74	5003.0-4.0	0.4	0.3	<0.1	3.7	48.6	48.6	2.76	DOL SHY SHLAM
75	5004.0-5.0	5.3	4.4	<0.1	9.0	31.8	34.4	2.83	DOL SL/SHY PF STY
76	5005.0-6.0	21.	19.	2.1	11.8	16.8	35.5	2.82	DOL SL/ANHY PF
77	5006.0-7.0	19.	19.	17.	17.6	21.4	39.7	2.84	DOL SL/ANHY PF
78	5007.0-8.0	0.5	0.5	0.4	17.3	23.6	43.3	2.82	DOL SL/ANHY STY
					11.5	21.5	49.5	2.80	DOL SL/ANHY PF

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**CORE LABORATORIES, INC.**  
*Petroleum Reservoir Engineering*

DALLAS, TEXAS

PAGE 4 OF

TEXACO, INC.  
BOB SLAUGHTER BLOCK 329

DATE : 1-24-81  
FORMATION : SAN ANDRES

FILE NO : 3202-12123  
ANALYSTS : REINHEIMER

**FULL DIAMETER ANALYSIS**

SAMPLE NUMBER	DEPTH FEET	PERM MAXIMUM	PERM 90 DEG	PERM VERTICAL	HE FOR	OIL% PORE	WTR% PORE	GRAIN DEN	DESCRIPTION
79	5008.0-9.0	1.5	1.3	0.4	11.5	36.0	25.6	2.83	DOL SL/ANHY PP SHLAM
80	5009.0-10.0	3.6	3.1	1.3	10.7	27.3	35.6	2.82	DOL SL/ANHY PP
81	5010.0-11.0	0.6	0.5	<0.1	7.9	12.6	52.8	2.80	DOL SL/ANHY PP SHLAM
82	5011.0-12.0	15.	8.8	9.0	13.5	19.9	35.4	2.82	DOL SL/ANHY SL/F PP
83	5012.0-13.0	15.	14.	7.7	12.1	19.4	41.4	2.82	DOL ANHY PP
84	5013.0-14.0	26.	25.	37.	19.1	25.1	42.8	2.82	DOL SL/ANHY VF PP
85	5014.0-15.0	2.2	1.3	0.9	11.5	17.2	45.5	2.82	DOL SL/ANHY VF PP SHLAM
86	5015.0-16.0	18.	17.	19.	17.4	18.4	42.7	2.82	DOL SL/ANHY PP
87	5016.0-17.0	5.7	5.5	9.0	14.0	18.6	39.0	2.82	DOL SL/ANHY PP FOSS
88	5017.0-18.0	6.9	6.4	4.8	13.8	23.9	28.3	2.84	DOL SL/ANHY PP FOSS
89	5018.0-19.0	3.9	3.8	0.6	14.0	22.9	40.1	2.83	DOL SL/ANHY SL/F PP SHLAM
90	5019.0-20.0	0.3	<0.1	<0.1	7.4	25.4	56.1	2.79	DOL SL/ANHY SL/SHY PP SHLAM
91	5020.0-21.0	21.	20.	12.	18.4	28.9	44.4	2.81	DOL SL/ANHY SL/F PP
92	5021.0-22.0	25.	22.	29.	15.2	15.5	44.5	2.79	DOL SL/ANHY SL/F PP FOSS
93	5022.0-23.0	2.6	2.0	1.7	10.8	14.8	42.6	2.81	DOL SL/ANHY PP FOSS
94	5023.0-24.0	2.4	2.1	<0.1	10.9	21.0	44.1	2.85	DOL SL/ANHY PP FOSS
95	5024.0-25.0	<0.1	<0.1	<0.1	10.7	8.6	65.6	2.89	DOL PP FOSS
96	5025.0-26.0	<0.1	<0.1	<0.1	9.2	17.3	48.7	2.89	DOL PP FOSS
97	5026.0-27.0	<0.1	<0.1	<0.1	7.4	13.0	58.0	2.88	DOL PP FOSS
98	5027.0-28.0	0.5	<0.1	<0.1	4.7	17.6	64.7	2.83	DOL SL/ANHY PP FOSS
99	5028.0-29.0	0.3	<0.1	<0.1	9.8	18.5	44.0	2.84	DOL SL/ANHY PP SHLAM FOSS
100	5029.0-30.0	<0.1	<0.1	<0.1	8.4	12.6	51.4	2.83	DOL SL/ANHY PP SHLAM
101	5030.0-31.0	<0.1	<0.1	<0.1	4.1	0.5	74.3	2.82	DOL SL/F PP SHLAM
102	5031.0-32.0	0.6	<0.1	<0.1	9.7	11.7	62.3	2.84	DOL F SHLAM STY
103	5032.0-33.0	<0.1	<0.1	<0.1	12.5	9.4	70.9	2.85	DOL SL/F PP SHLAM
104	5033.0-34.0	<0.1	<0.1	<0.1	6.0	22.5	71.9	2.84	DOL SL/ANHY SL/F PP FOSS
105	5034.0-35.0	2.7	2.7	<0.1	16.9	26.1	29.3	2.83	DOL SL/ANHY PP
106	5035.0-36.0	2.0	1.8	0.2	15.4	16.0	24.9	2.81	DOL SL/ANHY SL/V PP
107	5036.0-37.0	<0.1	<0.1	<0.1	9.8	14.8	39.1	2.77	DOL SL/ANHY SL/SHY SL/F PP SHLAM

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted), but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations, as to the productivity, proper operations, or profitability of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

**CORE LABORATORIES, INC.**  
*Petroleum Reservoir Engineering*  
DALLAS, TEXAS

PAGE 5 OF

TEXACO, INC.  
BOB SLAUGHTER BLOCK 329

DATE : 1-24-81  
FORMATION : SAN ANDRES

FILE NO : 3202-12123  
ANALYSTS : REINHEIMER

FULL DIAMETER ANALYSIS

SAMPLE NUMBER	DEPTH FEET	PERM MAXIMUM	PERM 90 DEG	PERM VERTICAL	HE FOR	OIL% FORE	WTR% FORE	GRAIN DEN	DESCRIPTION
108	5037.0-38.0	<0.1	<0.1	<0.1	4.9	19.3	50.6	2.78	DOL SL/ANHY SL/SHY VF PF SHLAM
109	5038.0-39.0	<0.1	<0.1	<0.1	4.3	32.8	37.3	2.78	DOL SHY SL/ANHY SL/CHTY SHLAM
110	5039.0-40.0	<0.1	<0.1	<0.1	5.7	35.3	25.5	2.78	DOL SHY SL/ANHY SHLAM
111	5040.0-41.0	0.2	0.2	<0.1	7.8	18.4	62.2	2.82	DOL SL/ANHY F PF FOSS
112	5041.0-42.0	<0.1	<0.1	<0.1	5.3	16.5	67.6	2.83	DOL SL/ANHY SL/F PF SHLAM FOSS
113	5042.0-43.0	0.9	0.4	<0.1	9.3	23.1	30.1	2.85	DOL SL/ANHY FOSS
114	5043.0-44.0	1.8	1.8	0.6	10.7	14.4	32.3	2.86	DOL SL/ANHY PF
115	5044.0-45.0	4.6	4.5	0.1	12.9	20.7	35.1	2.82	DOL SL/ANHY SL/F PF
116	5045.0-46.0	6.3	6.1	3.1	13.5	17.0	32.3	2.83	DOL SL/ANHY PF FOSS
117	5046.0-47.0	5.1	4.6	4.2	14.4	16.8	28.6	2.84	DOL SL/ANHY PF FOSS
118	5047.0-48.0	<0.1	<0.1	<0.1	5.0	17.6	40.5	2.77	DOL SHY SL/ANHY PF SHLAM
119	5048.0-49.0	9.8	8.9	0.3	13.6	18.9	29.9	2.81	DOL SL/ANHY PF
120	5049.0-50.0	10.	9.2	6.0	15.7	15.4	24.3	2.82	DOL SL/ANHY PF FOSS
121	5050.0-51.0	22.	19.	51.	17.0	21.3	24.4	2.84	DOL SL/ANHY PF FOSS

\* INDICATES PLUG PERMEABILITY

LUKE LABORATORIES, INC.  
*Petroleum Reservoir Engineering*  
 DALLAS, TEXAS

LITHOLOGICAL ABBREVIATIONS

ANH(Y)	ANHYDRITE, ANHYDRITIC	LAM	LAMINATED
ARK	ARKOSE, ARKOSIC	LM(Y)	LIMESTONE, LIMY
BAN	BAND, BANDED	MG	MEDIUM GRAINED
BREC	BRECCIA, BRECCIATED	MTX	MATRIX
CALC	CALCITE, CALCAREOUS	NOD	NODULE, NODULAR
CARB	CARBONACEOUS	QOL	ODOLITIC
CG	COARSE GRAINED	PISO	PISOLITIC
CHK(Y)	CHALK, CHALKY	PF	PINPOINT POROSITY
CHT(Y)	CHERT, CHERTY	PT	PARTING
CONGL	CONGLOMERATE, CONGLOMERITIC	PYR	PYRITE, PYRITIC
CXLN	COARSELY CRYSTALLINE	SD(Y)	SANDSTONE, SANDY
DNS	DENSE	SH(Y)	SHALE, SHALY
DOL(C)	DOLOMITE, DOLOMITIC	SHR	SOLID HYDROCARBON RESIDUE
F	RANDOMLY ORIENTED FRACTURES	SL/	SLIGHTLY
FG	FINE GRAINED	SLT(Y)	SILTSTONE, SILTY
FOSS	FOSSILIFEROUS	STY	STYLOLITE, STYLOLITIC
FR	FRIABLE	SUC	SUCROSCIC
FXLN	FINELY CRYSTALLINE	SUL	SULPHUR
GAL	GALENA	TBFA	TOO BROKEN FOR ANALYSIS
GLAUC	GLAUCONITE, GLAUCONITIC	TRIP	TRIPOLITE
GRAN	GRANITE	V/	VERY
GRAN WASH	GRANITE WASH	VF	FREEDOMINANTLY VERTICALLY FRACTURED
GYP	GYPSUM, GYPSIFEROUS	VGY	VUGULAR
HIF	PREDOMINANTLY HORIZONTALLY FRACTURED	XBD	CROSSBEDDED
INC	INCLUSION	XLN	MEDIUM CRYSTALLINE
INTBD	INTERBEDDED	XTL	CRYSTAL

THE FIRST WORD IN THE DESCRIPTION COLUMN OF THE CORE ANALYSIS REPORT DESCRIBES THE ROCK TYPE. FOLLOWING ARE ROCK MODIFIERS IN DECREASING ABUNDANCE AND MISCELLANEOUS DESCRIPTIVE TERMS.

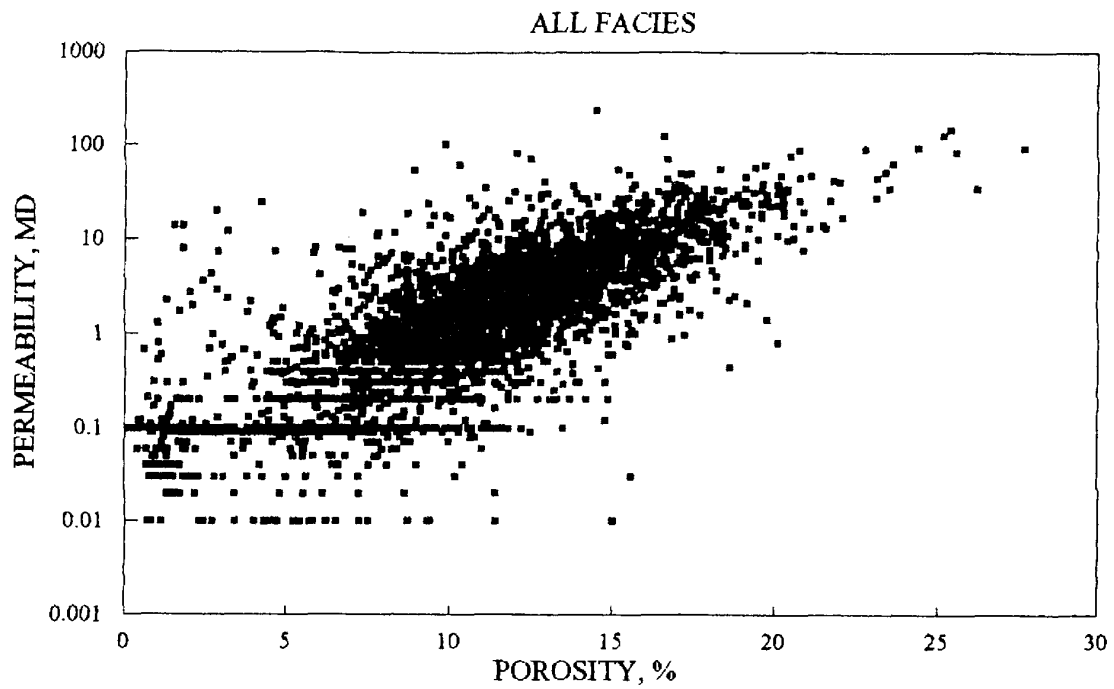


FIGURE 13. REGRESSION COEFFICIENT = 0.61

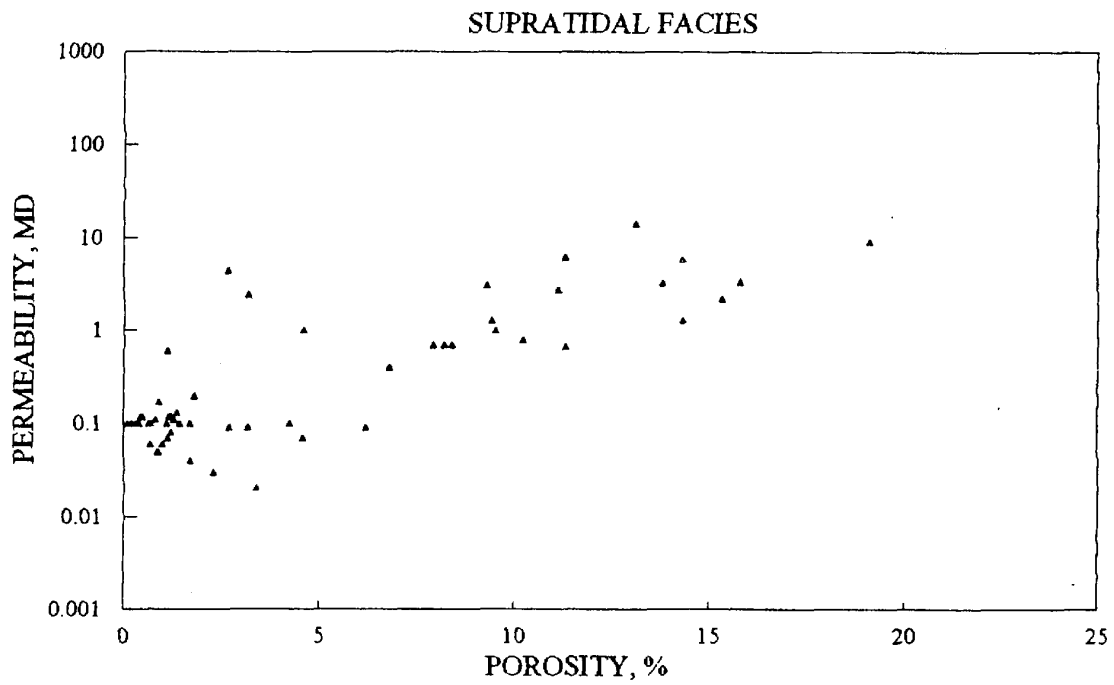
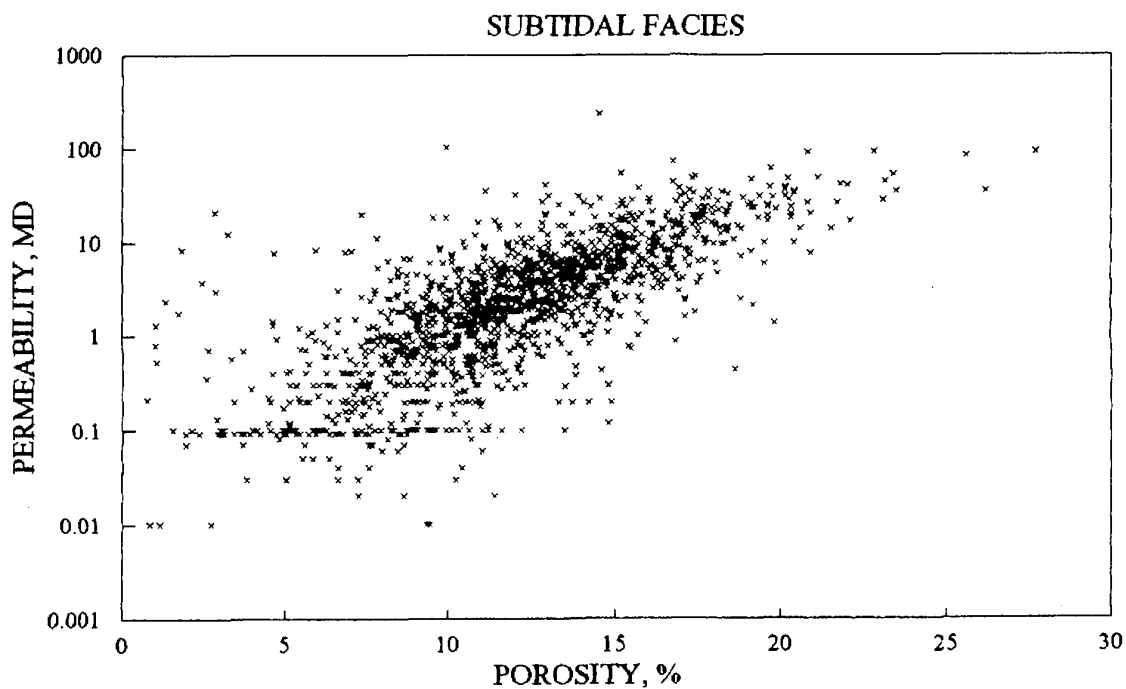
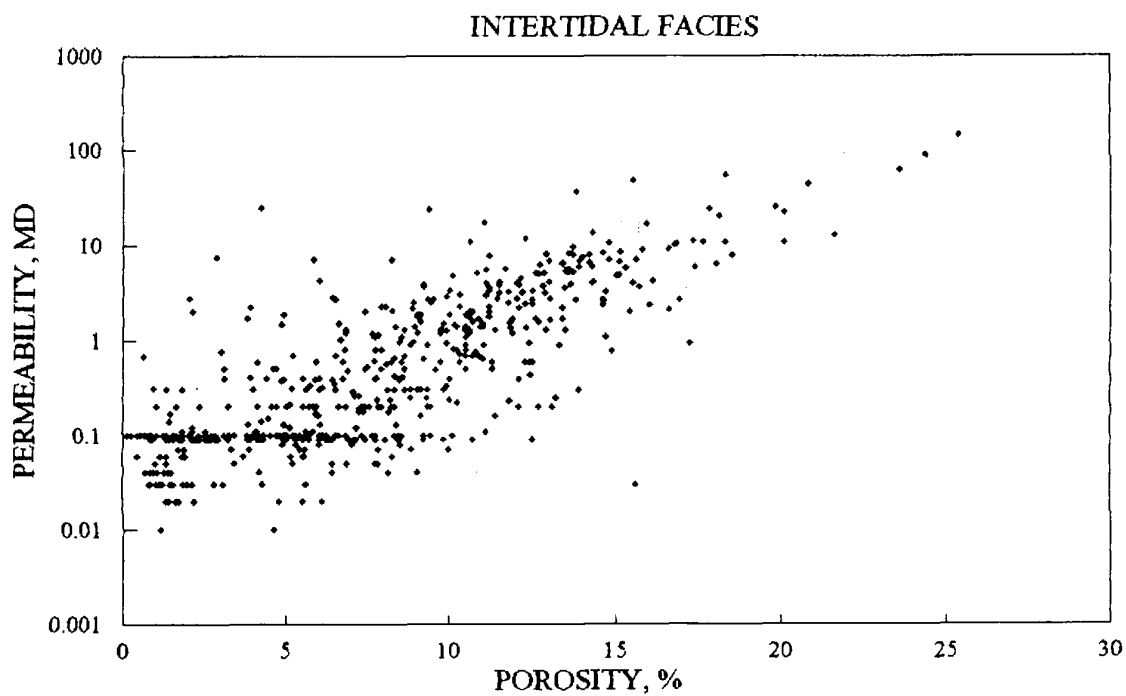


FIGURE 14. REGRESSION COEFFICIENT = 0.69



POROSITY, %

<u>Facies</u>	<u>High</u>	<u>Low</u>	<u>Average</u>
Supratidal	19.1	0.1	4.4
Intertidal	25.4	0.1	7.9
Subtidal	27.7	0.7	11.8
All facies	27.7	0.1	10.6

PERMEABILITY, md

<u>Facies</u>	<u>High</u>	<u>Low</u>	<u>Average</u>
Supratidal	14	0.02	1.10
Intertidal	148	0.01	2.64
Subtidal	235	0.01	5.70
All facies	235	0.01	4.40

TABLE 1.

**WELL  
COMPLETION  
REPORT**



Type or print only

# RAILROAD COMMISSION OF TEXAS

Oil and Gas Division

Form W-2

Rev. 4/1/83

481-046

API No. 42-219-34142

7. RRC District No.

8A

8. RRC Lease No.

06102

## Oil Well Potential Test, Completion or Recompletion Report, and Log

1. FIELD NAME (as per RRC Records or Wildcat)

Slaughter

2. LEASE NAME

Bob Slaughter Block

9. Well No.

341

3. OPERATOR'S NAME (Exactly as shown on Form P-5, Organization Report)

TEXACO Inc.

RRC Operator No.

844110

10. County of well site

Hockley

4. ADDRESS

P. O. Box 728, Hobbs, New Mexico 88240

11. Purpose of filing

Initial Potential



5. If Operator has changed within last 60 days, name former operator

Retest



Reclass

Well record only  
(explain in Remarks)

6a. Location (Section, Block, and Survey)

Labor 62, LGE 39, Maverick CSL

6b. Distance and direction to nearest town in this county.

1 mile west of Sundown, Texas

12. If workover or reclass, give former field (with reservoir) & gas ID or oil lease no.  
FIELD & RESERVOIRGAS ID or  
OIL LEASE #Oil - O  
Gas - G

WELL NO.

13. Type of electric or other log run

GR-CNL

14. Completion or recompletion date

12-22-83

### SECTION I: POTENTIAL TEST DATA IMPORTANT: Test should be for 24 hours unless otherwise specified in field rules.

15. Date of test 1-10-84	16. No. of hours tested 24	17. Production method (Flowing, Gas Lift, Jetting, Pumping— Size & Type of pump) 2-1/2" x 2" x 24			18. Choke size
19. Production during Test Period	Oil - BBLS 126	Gas - MCF 52	Water - BBLS 537	Gas - Oil Ratio 411	Flowing Tubing Pressure FSI
20. Calculated 24- Hour Rate	Oil - BBLS 126	Gas - MCF 52	Water - BBLS 537	Oil Gravity—API—60° 30.5	Casing Pressure PSI
21. Was swab used during this test? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>		22. Oil produced prior to test (New & Reworked wells) 151 BNO			23. Injection Gas—Oil Ratio
REMARKS:					

INSTRUCTIONS: File an original and one copy of the completed Form W-2 in the appropriate RRC District Office within 30 days after completing a well and within 10 days after a potential test. If an operator does not properly report the results of a potential test within the 10-day period, the effective date of the allowable assigned to the well will not extend back more than 10 days before the W-2 was received in the District Office. (Statewide Rules 16 and 51) To report a completion or recompletion, fill in both sides of this form. To report a retest, fill in only the front side.

#### WELL TESTER'S CERTIFICATION

I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I conducted or supervised this test by observation of (a) meter readings or (b) the top and bottom gauges of each tank into which production was run during the test. I further certify that the potential test data shown above is true, correct, and complete, to the best of my knowledge.

*[Signature]*  
Signature: Well Tester

Name of Company

RRC Representative

#### OPERATOR'S CERTIFICATION

I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this report, that this report was prepared by me or under my supervision and direction, and that data and facts stated therein are true, correct, and complete, to the best of my knowledge.

J. A. Schaffer

Assistant District Manager

Typed or printed name of operator's representative

505 392-7191

Title of Person

Telephone: Area Code

Number

Date:

01 / 19 / 84

mo. day year

Signature

*[Signature]*

SECTION II				DATA ON WELL COMPLETION AND LOG (Not Required on Retest)			
24. Type of Completion: New Well <input checked="" type="checkbox"/> Deepening <input type="checkbox"/> Plug Back <input type="checkbox"/> Other <input type="checkbox"/>				25. Permit to Drill, Plug Back or Deepen DATE 11-17-83 PERMIT NO. 94886			
26. Notice of Intention to Drill this well was filed in Name of TEXACO Inc.				Rule 37 Exception Water Injection Permit Salt Water Disposal Permit Other			
27. Number of producing wells on this lease in this field (reservoir) including this well 285		28. Total number of acres in this lease 6220					
29. Date Plug Back, Deepening, WorkOver or Drilling Operations: 12-15-83		Commenced 12-22-83		Completed 752' NW			
31. Location of well, relative to nearest lease boundaries of lease on which this well is located 1046 Feet From North Line and 886 Feet from West Line of the Bob Slaughter Block Lease							
32. Elevation (DF, RKB, RT, GR, ETC.) K.B. 3580				33. Was directional survey made other than Inclination (Form W-12)? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No			
34. Top of Pay 4950'	35. Total Depth 5032'	36. P. B. Depth 5029'	37. Surface Casing Determined by: <input type="checkbox"/> Field Rules <input checked="" type="checkbox"/> Recommendation of T.D.W.R. Railroad Commission (Special)		Dt. of Letter 8-24-83		
38. Is well multiple completion? No		39. If multiple completion, list all reservoir names (completions in this well) and Oil Lease or Gas ID No. FIELD & RESERVOIR			40. Intervals Drilled 0-5032'		
41. Name of Drilling Contractor Sojourner Drilling Co.				42. Is Cementing Affidavit Attached? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			
43. CASING RECORD (Report All Strings Set in Well)							
CASING SIZE	WT #/FT.	DEPTH SET	MULTISTAGE TOOL DEPTH	TYPE & AMOUNT CEMENT (sacks)	HOLE SIZE	TOP OF CEMENT	SLURRY VOL. cu. ft.
8-5/8"	24#	2242'		1100 sx C1 "H"	12-1/4	Circ	1594
5-1/2"	17#	5032'		1120 sx C1 "H"	7-7/8	Circ	2122
44. LINER RECORD							
Size	TOP		Bottom		Sacks Cement		Screen
45. TUBING RECORD				46. Producing Interval (this completion) Indicate depth of perforation or open hole			
Size	Depth Set	Packer Set	From	4950'		To	5016'
2-7/8"	4877'	SN 4909	From			To	
			From			To	
			From			To	
47. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.							
Depth Interval			Amount and Kind of Material Used				
4950 - 5016'			Acidize perms w/9800 gallons 20% NE acid, 2 drums SP-252 scale inhibitor & 56, 1.3 SPGR ball sealers				
48. FORMATION RECORD (LIST DEPTHS OF PRINCIPAL GEOLOGICAL MARKERS AND FORMATION TOPS)							
Formations	Depth		Formations	Depth			
Anhydrite	2200		San Andres	4950'			
Salts	2220						
Yates	2812						
REMARKS Perf 5-1/2 csg w/2 JSPI @ 4950, 54, 66, 74, 81, 87, 90, 96, 5000, 03, 08, 12 & 16 (13 intervals - 26 holes)							